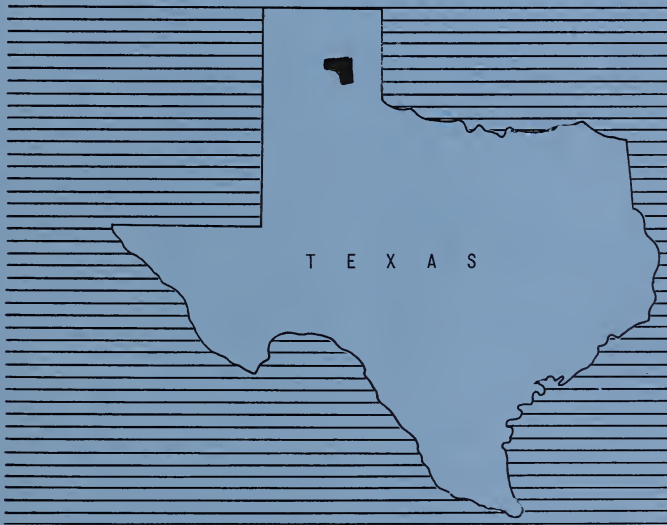
WORK PLAN
FOR
WATERSHED PROTECTION AND FLOOD PREVENTION

McCLELLAN CREEK WATERSHED

CARSON, GRAY, AND DONLEY COUNTIES, TEXAS



JANUARY 1967

4-24199 1-68
USDA-SCS-FORT WORTH, TEX. 1968

4-24199 5-67

WATERSHED WORK PLAN AGREEMENT

between the

Gray County Soil and Water Conservation District
Local Organization

Gray County Commissioners Court
Local Organization

McClellan Creek Soil and Water Conservation District
Local Organization

Carson County Commissioners Court
Local Organization

Donley County Soil and Water Conservation District
Local Organization

State of Texas
(hereinafter referred to as the Sponsoring Local Organization)

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the McClellan Creek Watershed, State of Texas under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the McClellan Creek Watershed, State of Texas, hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;

USDA-SCS-FORT WORTH, TEX. 1968
4-24199 1-68

Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about **five** years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire without cost to the Federal Government such land, easements, or rights-of-way as will be needed in connection with the works of improvement. (Estimated cost $ **322,483**.)

2. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.

3. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Construction Cost (dollars)
13 Floodwater Retarding Structures	**0**	**100.00**	**1,504,403**

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

Works of Improvement	Sponsoring Local Organization (percent)	Service (percent)	Estimated Installation Service Cost (dollars)
13 Floodwater Retarding Structures	0	100.00	320,053

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost $ 5,600 .)

6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.

7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.

8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.

9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual costs incurred in the installation of works of improvement will be used.

11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

    Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreement will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties hereto.

13. No member of Congress, or resident commissioner, shall be admitted to any share or part of this agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.

14. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C.F.R. Sec. 15.1-15.13), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving Federal financial assistance.

Gray County Soil and Water Conservation District
Local Organization

By Robert Taylor

Title Chairman

Date Nov. 1, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Gray County Soil and Water Conservation District
Local Organization

adopted at a meeting held on November 1, 1967

Curtis Dobroffsky
(Secretary, Local Organization)

Date NOV. 1, 1967

Gray County Commissioners Court
Local Organization

By S.R. Lemming Jr.

Title Gray County Judge

Date NOV. 1, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Gray County Commissioners Court
Local Organization

adopted at a meeting held on November 1, 1967

Chasie Thate County Clerk
(~~Secretary~~, ~~Local Organization~~)
By Doris Massie Deputy

Date November 1, 1967

COUNTY COURT OF GRAY COUNTY TEXAS

4-24199 1-68

McClellan Creek Soil and Water Conservation District
Local Organization

By R. J. Sailor Jr.

Title Chairman

Date Nov. 1, 1967

The signing of this agreement was authorized by a resolution of the governing body of the McClellan Creek Soil and Water Conservation District
Local Organization

adopted at a meeting held on Oct. 26, 1967

W. W. McGee
(Secretary, Local Organization)

Date Nov. 1, 1967

Carson County Commissioners Court
Local Organization

By [signature]

Title Carson County Judge

Date 11-1-1967

The signing of this agreement was authorized by a resolution of the governing body of the Carson County Commissioners Court
Local Organization

adopted at a meeting held on November 1, 1967

Fannie Williams County Clerk
(Secretary, Local Organization)

Date November 1, 1967

Donley County Soil and Water Conservation District
Local Organization

By T. C. D'Spain

Title Chairman

Date Nov. 1, 1967

The signing of this agreement was authorized by a resolution of the governing body of the Donley County Soil and Water Conservation District
Local Organization
adopted at a meeting held on November 1, 1967

Joe C. Kamff
(Secretary, Local Organization)

Date Nov. 1, 1967

_____
Local Organization

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the _____
Local Organization
adopted at a meeting held on _____

_____
(Secretary, Local Organization)

Date _____

Soil Conservation Service
United States Department of Agriculture

By _____

Date _____

WORK PLAN

FOR

WATERSHED PROTECTION AND FLOOD PREVENTION

McCLELLAN CREEK WATERSHED

Carson, Gray, and Donley Counties, Texas

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act, (Public Law 566, 83rd Congress; 68 Stat. 666), as amended.

Prepared By:

Gray County Soil and Water Conservation District
(Sponsor)

Gray County Commissioners Court
(Sponsor)

McClellan Creek Soil and Water Conservation District
(Sponsor)

Carson County Commissioners Court
(Sponsor)

Donley County Soil and Water Conservation District
(Sponsor)

With Assistance By:

U. S. Department of Agriculture
Soil Conservation Service
January 1967

4-24199 5-67
USDA SCS FORT WORTH TEX 1967

WATERSHED WORK PLAN

McCLELLAN CREEK WATERSHED

Carson, Gray, and Donley Counties, Texas

ADDENDUM

Since the preparation of this watershed work plan, the Federal interest rate for benefit and cost evaluations has been increased from 3.25 percent to 4.625 percent.

As a result, annual equivalent costs for the installation of these structural measures will increase from $72,928 to $100,631. The total average annual cost of structural measures (amortized total installation cost, plus other economic costs and operation and maintenance costs) will be increased to $131,910. Average annual benefits, excluding secondary benefits, accruing to structural measures will change to $139,684, resulting in a benefit-cost ratio of 1.1 to 1.0.

Total average annual project benefits, including secondary benefits, will change to $151,793, resulting in a benefit-cost ratio of 1.2 to 1.0.

4-24199 1-69
USDA-SCS-FORT WORTH, TEX. 1969

WATERSHED WORK PLAN

McCLELLAN CREEK WATERSHED

Carson, Gray, and Donley Counties, Texas
January 1967

SUMMARY OF PLAN

The work plan for watershed protection and flood prevention has been prepared by Gray County, McClellan Creek, and Donley County Soil and Water Conservation Districts and Gray and Carson County Commissioners Courts as sponsoring local organizations. Technical assistance has been provided by the Soil Conservation Service of the United States Department of Agriculture.

McClellan Creek watershed covers an area of 347.53 square miles (222,422 acres). It is estimated that 29.3 percent of the watershed is cropland, 2.7 percent is pasture and hayland, 65.9 percent is rangeland, and 2.1 percent is in miscellaneous uses such as public roads, farmsteads, and stream channels.

There are 1,449 acres of Federal land in the watershed. This area is known as the McClellan Creek Grassland which is part of the Panhandle National Grasslands and is administered by the Forest Service, United States Department of Agriculture.

Objectives of the proposed project are to provide flood protection for flood plain lands and to install proper land use and conservation practices in the interest of soil and water conservation. The project proposed in this work plan will accomplish these objectives.

Principal problems are the result of frequent flooding. Flooding that results in some damage occurs on the average of more than once per year. Severe floodwater damage to crops, grasses, farm improvements, and public roads and bridges occurs every two to three years. The floods also cause severe sediment and erosion damage to substantial amounts of flood plain land.

The cumulative area flooded during an average year of the 26-year evaluation period is about 3,745 acres. Average annual flood damages are estimated to be $82,921, including indirect damages. The proposed project will reduce these damages to an estimated $12,116 an average annual reduction of about 85 percent.

The work plan proposes installing, in a five-year period, needed land treatment measures and 13 floodwater retarding structures. Total storage capacity of structural measures will be 29,497 acre-feet, including 12,001 for sediment accumulation during a 100-year period and 17,496 for floodwater detention. An average of 1.77 inches of runoff will be detained from 53.5 percent of the watershed.

4-24199 11-68

Total project installation cost is estimated to be $2,851,415, including $698,876 for installation of planned land treatment and $2,152,539 for the structural measures. The local share is estimated to be $1,007,349 and the Public Law 566 share is estimated to be $1,844,066.

Public Law 566 cost share for the structural measures is estimated to be $1,824,456 and local share is estimated to be $328,083.

Total average annual benefits, resulting from installation of structural measures are estimated to be $149,845. Average annual cost for installation and maintenance of structural measures and other economic costs associated with project development is estimated to be $103,415. The benefit-cost ratio is 1.4 to 1.

Commissioners Courts of Carson and Gray Counties have powers of taxation and rights of eminent domain under applicable State laws and will furnish funds for financing local cost share of structural measures.

Operation and maintenance will be carried out by sponsoring local organizations. Funds for this purpose will be adequate and available from revenue supported by existing taxes. The value of average annual operation and maintenance expenses for structural measures is estimated to be $2,650.

4-24199 11-68

DESCRIPTION OF WATERSHED

Physical Data

McClellan Creek, a tributary of the North Fork of the Red River, is located in the Panhandle of Texas and includes portions of Carson, Gray, and Donley Counties.

The main stream of McClellan Creek originates in Carson County about five miles south of the city of Panhandle and begins a meandering course toward the east-southeast. It enters Gray County, makes a gradual turn to a northeasterly flow, passes through Lake McClellan, and enters the North Fork of the Red River at the eastern edge of Gray County. The only major tributary is North McClellan Creek, an easterly flowing stream which joins McClellan Creek in south central Gray County. There are many relatively short tributaries with steep gradients which join McClellan Creek from either side. The watershed comprises an area of 347.53 square miles (222,422 acres) of which 334 square miles (213,760 acres) are contributing drainage area.

The watershed lies within two major land resource areas. The eastern 75 percent is Central Rolling Red Plains. The western25 percent is Southern High Plains.

The Rolling Red Plains can be separated physiographically into two parts -- a rolling area and an escarpment area. The eastern 45 percent of the watershed is the rolling area and is characterized by smooth rolling hills and vegetated sand dunes. Predominant slopes range up to 10 percent, but steeper slopes occur on valley walls of larger streams. The central 30 percent of the watershed is escarpment area which presents an abrupt separation of the Rolling Red Plains from the elevated High Plains to the west. McClellan Creek and its tributaries have cut deep re-entrant canyons into the high plains. Slopes up to 35 percent are common.

The High Plains is characterized by a remarkably flat surface with a slight general slope toward the east-southeast. This is interrupted only by the narrow, shallow valley of McClellan Creek and numerous flat-bottomed basins or "playas". Drainage areas of such basins constitute the 13.53 square miles of non-contributing area in the watershed.

The nearly level flood plain is well defined throughout most of its length. The average flood plain width in the High Plains portion is about 1,000 feet. It narrows to an average width of 380 feet in western Gray County where the stream drops 250 feet from the High Plains into the Rolling Red Plains in a 13 mile segment. From this point, the flood plain gradually widens to a maximum width of 3,200 feet in the lower reaches. These widths include the stream channel which ranges from 200 to 1,200 feet wide in the lower 17 miles of McClellan Creek.

Elevations above mean sea level range from greater than 3,400 feet on the High Plains to about 2,480 feet at the confluence of McClellan Creek and North Fork of the Red River.

Most of the watershed is within the outcrop of the Ogallala formation, which is made up of extensive deposits of Pliocene outwash from the Rocky Mountains. It consists of somewhat cross-bedded, partially cemented sand, silt, clay, and gravel. Secondary deposits of caliche are common throughout the formation. Some caliche beds are indurated and much more resistant to erosion than underlying beds. They form a protective cap which serves to retard destruction of the nearly level plains surface by headward advancing streams. Quarternary deposits are significant in the following forms: a thin eolian mantle covering the surface of the High Plains; stabilized sand dunes in the eastern one-fourth of the watershed; and alluvium in natural basins, flood plains and stream channels. There are also minor outcrops of Permian red shales, sandstones, and conglomerates, which accounts for less than three percent of the watershed area. These outcrops occur at lower elevations in the eastern portion of the watershed and are a result of downward cutting of McClellan Creek and its tributaries.

Soils of the eastern portion of the watershed include deep fine sandy loams, loamy fine sands, and fine sands ranging from moderately permeable to rapidly permeable.

Soils of the escarpment area include slowly to moderately permeable clay loams, loams, and fine sandy loams. They range from very shallow to deep but are predominantly shallow soils. There are conspicuous areas of badland and rough broken land, but they account for a small portion of the total escarpment area.

Most of the High Plains soils are uniform, deep, moderately fine textured, very slowly permeable, and fertile.

The dominant soil series of the watershed are Pullman, Mansker, Mobeetie, Potter, Miles, Springer, Likes, Tivoli, Bippus, Lincoln, Spur, and Sweetwater.

The following tabulation shows land use in the watershed.

Land Use	Acres	Percent
Cropland	65,070	29.3
Pasture	6,084	2.7
Rangeland	146,490	65.9
Miscellaneous 1/	4,778	2.1
Total	222,422	100.0

1/ Includes roads, highways, railroad rights-of-way, farmsteads, stream channels, etc.

The Forest Service, United States Department of Agriculture, administers McClellan Creek Grassland which is a portion of the Panhandle National Grasslands. McClellan Creek Grassland includes Lake McClellan, with 325 acres of surface area, and 1,124 acres of grassland surrounding the lake. This area serves the purpose of water based recreation, livestock grazing, wildlife and watershed management, and oil and gas production.

4-24199 1-68

Hydrologic cover conditions on the watershed range from poor to good on rangeland, with an estimated 75 percent in fair condition. Range sites within the watershed are Deep Hardland, Hardland Slopes, Mixedland Slopes, Sandyland, Very Shallow, Rough Broken, and Bottonland. When these sites are in excellent condition, dominant grasses are sideoats grama, little bluestem, sand bluestem, blue grama, western wheatgrass, vine-mesquite, switchgrass, indiangrass, and buffalograss. Some deterioration has taken place because of overgrazing. Buffalograss, threeawn grasses, and hairy grama have increased on land that was originally in bluestems. Also, there has been some increase of mesquite, sand sagebrush, yucca, shinnery, and pricklypear.

Juniper trees are scattered throughout the escarpment area. Cottonwoods, elms, hackberrys, and wild plums are common along the lower reaches of McClellan Creek.

Fish and wildlife habitat and population are described by the Bureau of Sport Fisheries and Wildlife as follows:

> "McClellan Creek has sufficient water to support moderate amounts of minnows and small sunfish in the portion of the stream between Lake McClellan and the Red River. The volume of water is not sufficient, however, to support fishable populations of game fish.
>
> White-tailed deer, wild turkey, bobwhite, and scaled quail are the principal game species in the watershed. Deer and turkeys occur in moderate numbers in the lower portion of the watershed. They are expanding their range to other portions of the watershed where suitable habitat prevails and their numbers are expected to increase significantly in the future.
>
> Scaled quail occur in the upper portion of the watershed. Bobwhites are distributed throughout the watershed with the largest concentration occurring in the lower part of the watershed. Habitat conditions and populations of these birds are not expected to change significantly without the project.
>
> McClellan Creek Watershed lies within the former range of the lesser prairie chicken, a species now classified as rare by the Bureau of Sport Fisheries and Wildlife. Remnant populations of this species occur on suitable habitat in portions of Gray and Wheeler Counties which lie fairly near to the McClellan Creek Watershed. Gray County has only a few birds. There is a fair population throughout Wheeler County. It is fairly certain that no lesser prairie chickens remain in any portion of the McClellan Creek Watershed."

The climate is semi-arid. Summers are warm and clear. Winters are fairly mild. However, the region is subject to rapid and wide changes in temperature. These changes occur especially during winter months when masses of cold air surge southward over the unsheltered plains. Mean monthly temperatures range from 36 degrees Fahreheit in January to 79 degrees in July. The normal growing season, extending from about April 17

to October 31, is 197 days. Average annual precipitation is a little more than 20 inches. Average annual snowfall is about 12 inches. About three-fourths of total precipitation falls between April and September, mostly in the form of local thunderstorms frequently accompanied by strong wind and hail. Three to five tornadoes generally occur each year.

Wells are the principal source of water for irrigation, rural domestic, and livestock use. Municipal water supplies for Groom and McLean, located just outside the watershed, are also obtained from wells. The main water bearing sands are within the Ogallala formation and valley alluvium of McClellan Creek.

Economic Data

The economy of the watershed depends to a large extent on agriculture. Production and sale of cash crops of wheat and grain sorghum and the production and sale of beef cattle are the primary sources of income. However, considerable income is derived from crude oil and natural gas production at the present time.

Generally, the western portion of the watershed is devoted to the production of cash crops while ranching is the primary agricultural activity in the eastern portion. Irrigation water from wells sustain high level yields of wheat and grain sorghum on much of the cropland. Irrigation in the eastern portion of the watershed is applied mostly to improved pastures and hay crops. The principal hay crops are alfalfa and sorghums, in addition to the native grass hay fields. Small grain is planted for supplemental pasture on some land and wheat fields are used extensively for grazing during winter months.

It is expected that the present land use and crop distribution will continue; however, some of the marginal cropland will be converted to grassland.

The ground water supply for irrigation will gradually decline. It has been estimated that the supply will be depleted by the year 2000 at the present rate of use. More careful use of the water will extend this period.

Very little flood plain land is irrigated since a sub-irrigated condition exists in most of the Gray County portion. Since the water table is too high in some areas for maximum use of flood plain land, a slight lowering of the water table would improve the sub-irrigated condition. Slight stream channel degradation, expected as a result of the installation of a flood prevention project would cause some lowering of the water table. High level yields from hay fields and pastures in the flood plain, downstream from Lake McClellan, will be possible without irrigation.

Grain sorghum and wheat are the crops in surplus supply that are produced in the watershed. Acreage now devoted to these crops is significant to the watershed economy and to producers who depend upon these crops for a major portion of the family income.

There are approximately 288 farms and ranches in the watershed. Based on information contained in the United States Census of Agriculture, the

following tabulations show information for farm and ranch units in Carson and Gray Counties. It is believed the County estimates are applicable to the watershed area.

Subject	Carson County			Gray County		
Year	1954	1959	1964	1954	1959	1964
Average Size Unit (acres)	1,157	1,113	1,240	1,071	1,409	1,465
Average Total Unit Value (Dollars)	77,873	108,898	188,771	68,235	77,898	129,385
Average Value Per Acre (Dollars)	76	102	155	52	56	88

All farms are an economical unit and none have sales of less than $3,000 annually. Very few operators work off-farm for 100-days or more during the year. Estimated value of agricultural land in the watershed ranges from about $90 to $450 per acre.

Pampa, McLean, Groom, LeFors, White Deer, and Panhandle are the principal market centers serving the watershed. Large quantities of agricultural commodities are stored and processed in these centers where most of the employment opportunities for workers are provided.

The Carson County population increased slightly between 1960 and 1965 and the population of Gray County decreased slightly during the same period. It is expected these trends will continue for a period of time in the immediate future. The rural population is expected to continue to decline slightly.

Transportation facilities providing service to the area are the Atchinson, Topeka, and Santa Fe and the Chicago, Burlington, and Qunicy Railroads; and U. S. Highway 66 and State Highway 70. Farm-to-Market roads and improved county roads provide good travel routes within the watershed. There is a total of about 68 miles of hard surface roads that pass through the watershed.

Very limited water based recreation facilities, other than Lake McClellan, are available to attract tourists.

Good opportunities will exist in the future for development of better wildlife habitats in addition to the opportunities for increased water based recreation activities.

Land Treatment Data

The Gray County, Donley County, and McClellan Creek Soil and Water Conservation Districts are assisting farmers and ranchers of the watershed in preparation and application of basic soil and water conservation plans on their

land. Soil Conservation Service work units at Pampa, Panhandle, and Clarendon are assisting these three districts. There are 288 operting units, of which 267 are under district agreement. The land under district agreement is 97 percent of the agricultural land in the watershed.

Work units have assisted district cooperators in preparing 213 basic soil and water conservation plans, covering 84 percent of the agricultural land in the watershed, and have given technical assistance in establishing and maintaining planned measures (table 1A). Current revision is needed on 150 conservation plans. Soil surveys have been completed in Gray and Carson Counties and a few farms have been surveyed in the Donley County portion of the watershed.

It is estimated that 70 percent of total needed land treatment has been applied and that more than 65 percent of the land is adequately treated. The National Grassland land is adequately treated and no additional treatment is necessary. The level of land treatment applied is expected to reach greater than 90 percent in 5 years as a result of the planned land treatment program.

WATERSHED PROBLEMS

Floodwater Damage

There are approximately 9,412 acres of flood plain land, including about 1,748 acres of sand filled channel of McClellan Creek. This 9,412 acres is that area inundated by an estimated 100-year frequency flood. The area, excluding channels, inundated by runoff from the largest storm considered in the 26-year evaluation period was 5,738 acres. Included are 2,036 acres in reach 1, 260 acres in reach 2, 1,228 acres in reach 3, 469 acres in reach 4, and 1,745 acres in reach 5 (figure 1). When recurrent flooding is considered, the cumulative area flooded during an average year is estimated to be 3,745 acres. The market value of flood plain land is estimated to range from $100 to $400 per acre.

Floods that result in damage occur on the average of more than one per year. Severe damage to hay crops, pastures, fences, farm roads and creek crossings, livestock, and public roads and bridges occur every two to three years. Debris is deposited on land and on roads and bridges causing inconveniences and extra expenses for clean up and removal of the trash following floods. Flooding and sediment deposition has limited the use of much of the fertile subirrigated flood plain land. A majority of the land, especially downstream from Lake McClellan, was formerly used for hay production but at present time is used as rangeland.

During the 26-year period (1940 to 1965), there were 15 major floods, each inundating more than half the flood plain. In addition, there were 18 minor floods covering less than half the flood plain. Floods often develop quickly in this area, and the rapid runoff from the steep escarpment areas causes peaks and high velocity of floodwater that is very destructive to the land and to improvements in the flood plain.

Local efforts to reduce damages by attempting to straighten, direct, and confine channel flow have met with some success. The adverse economic and

Floodwater damage to county road low water crossing located downstream from Lake McClellan. Note temporary earth fill on right end of crossing to allow traffic over the road.

Floodwater damage to bridge on Farm-to-Market Road 273 across McClellan Creek.

4-24199 5-67

physical effect of flooding has been felt throughout the watershed, and will prompt local participation in the alleviation of flood problems.

Recent major floods occurred in June 1961, October 1960, July 1958, May 1957, June 1954, and May 1951. The 1957 and 1951 floods were the most damaging. The occurrence of a storm producing 1.0 to 1.5 inches of runoff, which would equal an estimated 5-year frequency event, will cause flooding over about 4,897 acres and inflict an estimated $28,968 in direct floodwater damages. An estimated 26-year frequency storm will cause flooding over about 5,738 acres and inflict an estimated $70,979 direct floodwater damages.

Based on floods that were considered in the 26-year historical series, average annual direct floodwater damages, without land treatment and structural measures applied, will total an estimated $32,921 (table 5). These damages, by individual evaluation reaches, are shown in the following tabulations.

Average Annual Direct Floodwater Damages Without Project

Evaluation Reach (Figure 1) Number	Damage in Dollars (Based on Adjusted Normalized Prices) Crop and Pasture	Other Agricultural	Road and Bridge	Total
1	18,245	4,832	-	23,077
2	218	61	462	741
3	1,710	1,224	2,190	5,124
4	141	372	186	699
5	1,728	675	877	3,280
TOTAL	22,042	7,164	3,715	32,921

Indirect damages resulting from flooding are considered to involve such items as restrictions in travel, delays and re-routing of school busses and mail deliveries, interference with recreation activities at Lake McClellan and inconvenience and delays in tending livestock. Indirect damages are estimated to average $7,539 annually.

There is some damage to wildlife habitat, especially the nesting areas of mourning dove, bobwhite, and turkey.

Floods have made expensive spillway repairs necessary at Lake McClellan.

Sediment Damage

Sediment damage is extremely high in the watershed. Channel and flood plain aggradation have resulted in loss of channel capacities, increased flood frequencies, and severe damage and destruction of flood plain land.

Prior to 1920, McClellan Creek flowed in a narrow, well defined channel. Farming practices of the 1920's and 1930's resulted in increased erosion rates. The additional sediment introduced into streams of the area initiated a process of channel filling and widening. At present, the lower

Floodwater damage and sediment deposition on flood plain land. Channel is filling with sand and widening.

Modern overbank deposition of coarse textured sediment on flood plain land.

4-24199 5-67

Aerial photograph showing about two miles of McClellan Creek near the confluence with North Fork of Red River. View indicates extent of sediment deposition and channel encroachment on flood plain land.

4-24199 5-67

17 miles of McClellan Creek consists of a shallow, braided channel with an average width of 700 feet and bedload of fine to medium grained sand. A rising water table in the flood plain has accompanied aggradation.

Overbank deposition of sediment occurs as deposits ranging in texture from medium grained sand to silty clay and in depth from 0.5 to 15.0 feet. The deeper and coarser textured deposits occur in lower reaches. The average thickness of overbank deposition in evaluation reach 1 (figure 1) is seven feet, and the predominant texture is slightly silty, fine to medium grained sand. It is estimated that overbank deposition causes loss of productive capacity on 2,893 acres of flood plain land. The following tabulation shows this damage by evaluation reaches:

Average Annual Acres Damaged by Overbank Deposition of Sediment

Evaluation Reach (figure 1):	Percent Reduction in Productive Capacity								Total Acres
	10	20	30	40	50	60	70	90	
1	0	0	164	166	431	841	209	138	1,949
2	0	0	0	137	0	0	69	0	206
3	51	124	0	98	17	3	0	29	322
4	64	123	0	0	0	0	0	0	187
5	229	0	0	0	0	0	0	0	229
Total Acres	344	247	164	401	448	844	278	167	2,893

The average annual value of this damage is estimated to be $33,453 (table 5).

As stream and flood plain aggradation continue in evaluation reaches 1, 2, and 3, overbank deposits progress toward the outer edges of the flood plain. Channel widening, occurring simultaneously with this process, converts land formerly damaged by overbank deposition to stream channel. The net effect is estimated to be an equal amount of overbank deposition damage annually. Damage by land loss due to channel widening is included under Erosion Damage.

Sediment deposited in Lake McClellan is estimated to average 35 acre-feet per year. The estimated average annual value of the damage caused by loss of storage capacity is $3,500 (table 5).

Altus Reservoir is located downstream from McClellan Creek watershed on North Fork of the Red River near Altus, Oklahoma. It is estimated that an average of 22 acre-feet of sediment per year, derived from McClellan Creek watershed is deposited in Altus Reservoir. This is two percent of the total average annual sediment deposition in Altus Reservoir.

Erosion Damage

Upland erosion rates in the watershed range from low to high. The highest rates occur in the escarpment portion of the Central Rolling Plains Land Resource Area and average 4.1 acre-feet per square mile annually. The lowest rates occur in the rolling, sandy portion of the Rolling Plains and in the High Plains where annual erosion rates are estimated to be 1.0 and

1.1 acre-feet per square mile, respectively. Of total upland erosion, sheet erosion accounts for 83 percent, gully erosion 12 percent, and streambank erosion 5 percent.

Gully and streambank erosion account for 23 percent of total upland erosion in the Central Rolling Plains Land Resource Area. A cycle of channel development is occurring on lateral tributaries. This cycle was preceeded by a period of pronounced valley filling, as indicated by the thick alluvium through which gullies are now advancing. Smooth, grassed valleys without channels exist upstream from headcuts. Channel banks are becoming vegetated rapidly after passage of headcuts.

The main stream, unable to efficiently transport incoming sediment from the upland, is aggrading. The aggradation is a direct cause of severe streambank erosion. As bedload is deposited in the channel, flood flows attack streambanks with increased force. In the last 45 years, a narrow, well developed channel in evaluation reach 1 (figure 1) has been transformed into a broad, sand filled, braided channel ranging from 200 to 1,200 feet wide.

It is estimated that this type of streambank erosion has caused a loss of 820 acres. The process is still active and advancing into evaluation reaches 2 and 3. The projected land loss by streambank erosion, under existing conditions, during the next 100 year period is 900 acres in reach 1; 217 acres in reach 2; and 800 acres in reach 3. The average annual value of this damage is estimated to be $5,450 (table 5).

The area affected by flood plain erosion is small. Most of the damaged areas consist of shallow depressions ranging from 50 to 300 feet wide and are limited to evaluation reaches 3, 4, and 5. It is estimated that the productive capacity of 193 acres is being reduced 10 percent annually by scour.

Annual recovery from flood plain scour is approximately in balance with new damage. The average annual value of this damage is estimated to be $58 (table 5).

Problems Relating to Water Management

Surface drainage of agricultural land is not a major problem. However, flat-bottomed basins or "playas" with no outlets are located on the plains surface. Use of these basins for crop production is very limited because of wetness.

At present about 7,000 acres are irrigated from wells in the watershed. Water is obtained from the Ogallala formation and is generally of good chemical quality suitable for irrigation and domestic use.

Sponsoring local organizations expressed a desire for storage of municipal water supply and water-based recreation. However, inadequate water yield and poor water-holding potential at reservoir sites prevented development of these desires.

PROJECTS OF OTHER AGENCIES

McClellan Dam, located near the central portion of the watershed on McClellan Creek, was completed in 1940 for the purpose of water-based recreation. The lake, with a surface area of 325 acres and a capacity of 4,300 acre-feet, is located on 1,449 acres of National Grassland and operated by the Forest Service, United States Department of Agriculture.

Altus Reservoir, located about 100 miles downstream from McClellan Creek watershed near Altus, Oklahoma, was built by the Bureau of Reclamation for water conservation storage to serve the W. C. Austin project. This project provides water for the city of Altus, Altus Air Force Base, and the Lugert-Altus Irrigation District.

BASIS FOR PROJECT FORMULATION

An initial study was made by representatives of the Soil Conservation Service and sponsoring local organizations to determine watershed problems and possible solutions.

Meetings were held with the sponsoring local organizations to discuss existing flood and sediment problems, water and related land resource development needs, and to formulate project objectives. Watershed protection, flood prevention, sediment detention, municipal water development, and water-based recreation were the primary objectives desired by the sponsors.

The following specific objectives were agreed to:

1. Establish land treatment measures which contribute directly to watershed protection and flood prevention and would make the watershed an outstanding example of soil and water conservation.

2. Attain a reduction of 70 to 75 percent in average annual flood and sediment damages through installation of structural works of improvement to supplement land treatment on the watershed. Approximately 15 potential structure sites will be investigated in determining the most feasible system of measures.

3. Investigate the feasibility of including storage of water for municipal and recreational use for Groom and McLean in multiple-purpose structures. The water stored for municipal purposes would be used as a supplemental source to the present supply.

The land treatment program is to include conversion of some marginal cropland to grassland. Shifts of some rangeland and idle channel areas to production of hay and forage crops in the flood plain are expected to occur after structural measures are installed.

In selecting sites for floodwater retarding structures, consideration was given to locations which would provide the agreed upon level of protection

to areas subject to damage. The size, number, design, and cost of structures were influenced by physical, topographic, and geologic conditions.

The proposed works of improvement including both land treatment and structural measures meet project objectives at the least cost in providing the desired level of protection to agricultural areas. After full consideration of geologic and hydrologic conditions, the proposed multiple-purpose sites nos. 2 and 13 were found not to be feasible for storing recreational and municipal water. This is due to (1) the unfavorable water-holding characteristics of the underlying formations and (2) inadequate water yields in the drainage areas of the structure sites.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Gray County, McClellan Creek, and Donley County Soil and Water Conservation Districts are assisting farmers and ranchers of the watershed in the preparation and application of basic soil and water conservation plans on their land. Application of measures in these plans, based on the use of each acre within its capabilities and its treatment in accordance with its needs, is an essential part of a sound program for watershed protection and flood prevention. The extent of needed land treatment measures which have been applied to date within the watershed represents an estimated expenditure of $1,311,341 (table 1a).

Table 1 includes estimates of the acreage in each major land use on which land treatment measures will be installed during the five-year project installation period. The measures will be established and maintained by landowners and operators in cooperation with Gray County, McClellan Creek, and Donley County Soil and Water Conservation Districts.

It is expected that nearly 1,300 acres will be converted from cropland to pasture and rangeland. Pasture and hayland planting and pasture and hayland management will be practiced on most of this land to reduce runoff rates and protect slopes from rapid erosion. Some of this land is expected to be converted to rangeland, in which case range seeding and range proper use will be practiced.

Cultivated land will be treated with a combination of measures in keeping with a conservation cropping system for soil conditioning and protection from wind and sheet erosion. Conservation cropping systems in this watershed include grasses and legumes in rotation, crop residue use, contour farming on terraced land, fertilizing, and stubble mulching. Terraces provided with grassed waterways or outlets will be installed to control erosion and retard runoff from the more rolling areas.

A good base cover of desirable forage plants will be attained by pasture and hayland planting and pasture and hayland management.

Proper use and deferred grazing will be practiced on rangeland to maintain adequate cover for soil protection and improve quantity and quality of desirable vegetation. Rangeland with infestations of woody plants will be

Excellent grass cover on McClellan Creek National Grassland following deferred grazing.

Range seeding of Indiangrass on Bottomland range site, McClellan Creek watershed.

4-24199 5-67

Irrigated bermudagrass pasture on McClellan Creek flood plain.

Sub-irrigated native hayland properly managed.

4-24199 5-67

either bulldozed, root plowed, or sprayed to control brush. Some of these areas will be seeded with range grasses. Destruction of cover caused by over-use around present watering places will be reduced by establishing farm ponds.

Diversions will be constructed to protect cropland, pasture, and rangeland from rapid runoff from steeper areas.

In addition, irrigated cropland and pasture will receive the following treatment: Irrigation land leveling; irrigation systems; irrigation pipeline; and irrigation water management. Combined effects of these measures will be reduced erosion, more efficient use of irrigation water, and increased net income to farm operators.

In addition to technical assistance presently available, $19,610 will be made available from Public Law 566 funds to accelerate establishment of land treatment practices and measures. Local people will continue to install and maintain measures needed in the watershed after the five-year installation period.

Installation of land treatment measures will reduce erosion and increase infiltration of rainfall as a result of improved ground cover in cultivated areas and increased grass density and vigor on pasture and rangeland. This makes possible reductions in the following: capacity required for sediment accumulation in structural measures; floodwater detention storage capacity provided in floodwater retarding structures; and floodwater and sediment damages on the flood plain.

Structural Measures

A system of 13 floodwater retarding structures will be installed to provide the needed flood protection in this watershed that cannot be attained by land treatment measures alone.

The major factors which will affect construction are: high water tables with permeable soils in the foundation at most site locations; zoning of available borrow material within the embankments for some structures; and lack of suitable rock rip-rap material within the watershed area.

Location of the structures is shown on the project map (figure 4). Figure 2 shows a section of a typical floodwater retarding structure. Tables 1, 2, and 3 show the details for quantities, costs, and design information for each structure.

Total storage capacity of the floodwater retarding structures is 29,497 acre-feet. Of this, 12,001 acre-feet is sediment storage and 17,496 acre-feet is detention storage. These structures will detain an average of 1.77 inches of runoff from 53.5 percent of the watershed. The sediment storage provided in the floodwater retarding structures is for the sediment accumulation for a 100-year period. Principal spillway crests of the various structures will be set at the elevation of the 50-year sediment pool. Pools exceeding 200 acre-feet in capacity will have the principal spillways ported at the 200 acre-feet elevation.

Several different types of utility improvements (oil and gas pipelines, oil wells, telephone and electric power lines, and county roads) are located within site pool areas. Some of these facilities will require relocation or reconstruction.

All applicable State laws will be complied with in design and construction of structural measures.

Total installation cost of the structural measures is estimated to be $2,152,539 (table 2).

EXPLANATION OF INSTALLATION COST

The total project installation cost is estimated to be $2,851,415, including $698,876 for land treatment measures and $2,152,539 for structural measures. The share from sources other than Public Law 566 funds is estimated to be $1,007,349 and the Public Law 566 share is estimated to be $1,844,066 (table 1).

Included in the local share of project installation costs are: $616,948 for landowners and operators expenses in applying land treatment measures which include anticipated financial assistance by the Agricultural Conservation Program and the Great Plains Conservation Program; $62,318 for technical assistance from Public Law 46 funds; $322,483 for land, easements, and rights-of-way expenses of structural measures; and $5,600 for contracts administration.

Included in the Public Law 566 share of project installation costs are: $19,610 for accelerated technical assistance; $1,504,403 for construction; and $320,053 for installation services of structural measures.

Cost of applying land treatment practices is based on present prices being paid by landowners and operators to establish the measures and were estimated by sponsoring local organizations.

Land, easements, rights-of-way, and contracts administration costs were determined by appraisal in cooperation with representatives of the sponsoring local organizations. These costs include the following: $204,193 for value of land needed for installation of structural measures; $113,090 for relocation and modification of existing improvements; $5,600 for contract administration; and $5,200 for value of legal services.

Relocation and modification of existing improvements involve the following: telephone lines at sites nos. 4 and 6; power lines at sites nos. 2 and 13; pipelines at sites nos. 3, 4, 6, 8, 9, 12, and 13; gas and oil wells at sites nos. 4, 6, and 8; Farm-to-Market Road at site no. 2; county roads at sites nos. 2 and 6; and private roads at sites nos. 4, 5, 6, 10, and 11.

Construction costs include the engineer's estimate and contingencies for constructing floodwater retarding structures. The engineer's estimates were based on unit costs of structural measures in similar areas modified by special conditions inherent to each individual site location. Included are such items as permeable foundation conditions, special placement of embankment material, need for protecting structures from wave actions, and

site preparation. Ten percent of the estimate was added as a contingency to provide funds for unpredictable construction costs.

Installation services cost include engineering and administrative services involved for installation of structural measures. These estimates were based on analysis of previous work in similar areas.

Following is the estimated schedule of obligations for the five-year installation period. No additional measures are to be applied on the McClellan Creek Grassland, consequently no funds are included for this purpose.

Fiscal Year	Measures	Public Law 566 Funds (Dollars)	Other Funds (Dollars)	Total (Dollars)
First	Land Treatment	3,922	135,854	139,776
	Floodwater Retarding Structure Nos. 6 and 7	422,210	55,750	477,960
Second	Land Treatment	3,922	135,853	139,775
	Floodwater Retarding Structure Nos. 1, 2, and 5	353,932	134,000	487,932
Third	Land Treatment	3,922	135,853	139,775
	Floodwater Retarding Structure Nos. 3, 4, and 8	394,954	82,563	477,517
Fourth	Land Treatment	3,922	135,853	139,775
	Floodwater Retarding Structure Nos. 9, 10, 11, and 12	465,768	40,720	506,488
Fifth	Land Treatment	3,922	135,853	139,775
	Floodwater Retarding Structure No. 13	187,592	15,050	202,642
TOTAL		1,844,066	1,007,349	2,851,415

This schedule may be adjusted from year to year to conform with appropriations, actual accomplishments, and any significant mutually desirable changes.

EFFECTS OF WORKS OF IMPROVEMENT

Owners and operators of approximately 75 farm and ranch units will be directly benefited because of reduced flood damages on about 9,412 acres of flood plain land, including the present channels. This is the area inundated by an estimated 100-year frequency flood. Irrigation farmers, located in the vicinity of structures, will benefit from additional ground water recharge

of the Ogallala formation. Public road and bridge repair and maintenance expenses in the flood plain will be reduced.

The combined program of land treatment and floodwater retarding structures will reduce the total average annual acres flooded by 58 percent.

Cumulative totals of average annual recurrent flooding will be reduced from 3,745 to 1,557 acres, a reduction of 2,188 acres.

The following tabulations illustrate the acres flooded by storms of specified frequencies without the project and with the complete project installed.

Evaluation Reach (Figure 1):	Estimated Acres Inundated by Specified Frequency 1/					
	26-Year		5-Year		2-Year	
	Without Project	With Project	Without Project	With Project	Without Project	With Project
1	2,036	1,170	1,661	624	1,238	507
2	260	41	208	35	87	22
3	1,228	520	1,013	376	575	300
4	469	392	417	358	371	304
5	1,745	1,000	1,598	721	930	444
TOTAL	5,738	3,123	4,897	2,114	3,201	1,577

1/ Excludes stream channel.

After installation of the project, the area inundated by runoff from the 26-year frequency storm will be reduced to a size smaller than the area inundated with an occurrence of a 2-year frequency event withou the project installed.

The direct floodwater damages resulting from an estimated 26-year frequency flood will be reduced from about $70,979 to an estimated $14,381. The project will reduce the damages for a 5-year frequency flood from $28,968 to about $7,105

Land treatment and structural measures will reduce 11 of the 15 major floods, that are estimated to occur during an average 26-year period, to minor floods. In addition, flooding will be eliminated or greatly reduced from the 18 minor flood producing storms that are expected to occur during the evaluation period.

The average annual volume of damaging sediment deposited upon the flood plain will be reduced an estimated 86 percent. About 22 percent of the reduction will result from installation of land treatment.

A 100 percent reduction in the net loss of flood plain land due to streambank erosion is expected to result from installation of the floodwater retarding structures. It is estimated that a gradual change to hayland will occur on about 655 acres of flood plain land that have already been captured by the channel because of streambank erosion. This erosion has resulted

from channel aggradation. After project installation slight channel degradation is expected to occur.

About 781 acres of present rangeland in the flood plain will be restored to its former use of hay and forage production. An additional 253 acres will be changed from rangeland to native hayland.

Application of the land treatment program will result in a shift of about 1,294 acres of marginal cropland in the upland areas to grassland.

Average annual sediment deposition in Lake McClellan will be reduced from 35 to 19 acre-feet. The average annual sediment yield to the Altus Reservoir, from this watershed, will be reduced from 22 to 8 acre-feet.

Studies conducted jointly by the Soil Conservation Service and the Bureau of Reclamation show that immediately after installation of the project, the average annual yield of water from Altus Reservoir could be reduced by an estimated maximum of 840 acre-feet. By the year 2000 the reduction could decline to an estimated maximum of 610 acre-feet annually as a result of expected sediment accumulation in the planned floodwater retarding structures. The present worth value of the reduction in water yield is estimated to average $27,837 annually and is shown as "Other Economic Costs" in table 4.

Bank cutting during flood flows results in wide, sand filled streambeds where large amounts of water are consumed by brush and other low value vegetation. Installation of floodwater retarding structures will result in narrower stream channels and decreased water losses.

Floodwater retarding structures will cause an additional 186,000 acre-feet of water to enter the Ogallala ground water formation during the 100-year period of project life.

The pools of reservoirs will provide additional livestock water in some areas of the watershed.

The sediment pools of at least six floodwater retarding structures will provide excellent opportunities for water-based recreation such as fishing, swimming, hunting, and picnicking. These pools, expected to be open for public use, will be enjoyed by an estimated 3,000 people resulting in about 20,000 visitor days use by the general public annually. Most of the usage will occur from May through September, but some use will be made of the facilities throughout the year.

The effects of the works of improvement on fish and wildlife habitat are described by the Bureau of Sport Fisheries and Wildlife as follows:

> "Construction of 13 floodwater retarding reservoirs in the watershed would provide additional fish habitat. If these reservoirs are properly managed and opened to the public for fishing, they would be fished heavily. These structures should also serve to prolong the useful life of Lake McClellan by reducing the amount of siltation accruing in that body of water. Silt reduction would benefit fish habitat.

The floodwater retarding structures would make available more permanent water and reduce flood damage to wildlife habitat downstream from the dams. The reservoirs also would provide resting habitat for migrating waterfowl.

The application of land treatment measures generally would improve wildlife habitat in the watershed. The stirring of soils would stimulate weed production which would be beneficial to bobwhites, scaled quail, and other seed-eating birds.

The proposed works of improvement are expected to have no effect on lesser prairie chickens. If they were present, they would be benefited by the increased permanent water and land treatment measures contemplated.

Brush control and clearing done in connection with construction of the floodwater retarding dams and reservoirs would destroy badly needed wildlife food and cover plants. This is a particular concern in view of the expanding wildlife populations in the watershed."

The project will create some additional employment opportunities for local residents. Employees will be needed for construction and for operation and maintenance of the structural measures. Secondary benefits, including increased business activities and improved economic conditions will result from the project. Local businesses will benefit from sales and services associated with more uniform production and marketing of agricultural goods. Sales of items needed for more water-based recreation activities will be stimulated.

PROJECT BENEFITS

Total average annual project benefits are estimated to be $160,423 distributed as follows:

Benefits	Dollars
Damage Reduction	70,805
Changed Land Use	17,789
Incidental	58,781
Altus Reservoir	1,091
Secondary	11,957

Application of land treatment measures will result in about $10,578 average annual benefits and the remaining $149,845 will result from installation of structural measures.

The estimated average annual monetary floodwater, sediment, erosion, and indirect damages within the watershed will be reduced from $82,921 to $12,116 by the proposed project. This is a reduction of 85 percent. Of the $70,805 damage reduction benefits attributable to the project, $60,460 results from the installation of structural measures and $10,345 results from the application and maintenance of needed land treatment measures.

It is estimated that the net increase in income from restoration of former productivity will amount to $14,823 annually. This loss from the original production has been included in crop and pasture damage and its restoration

a benefit in table 5.

Reduction in monetary flood damages and resultant benefits vary with respect to location within the flood plain. The following tabulation shows the general location of damage reduction benefits within the watershed attributable to the project.

Average Annual Damages and Benefits (Dollars)

Evaluation: Reach Number (figure 1)	Damages: Without Project	With Land Treatment	With Total Project	Benefits: From Land Treatment	From Structural Measures	Total
1	64,463	55,712	6,634	8,751	49,078	57,829
2	2,774	2,582	61	192	2,521	2,713
3	7,244	6,570	1,465	674	5,105	5,779
4	4,714	4,214	2,564	500	1,650	2,150
5	3,726	3,498	1,392	228	2,106	2,334
Total Watershed	82,921	72,576	12,116	10,345	60,460	70,805

It is estimated that the net increase in income resulting from changed land use will amount to $17,789 annually.

Benefits from incidental recreational use of the sediment pools of the floodwater retarding structures are estimated to be $7,607 annually. This is based on a gross value of $0.50 per visitor day, less associated costs, and discounted for the estimated useful life of the pools for recreational purposes.

The monetary value of the incidental ground water is estimated to be $50,443 annually.

Additional livestock water that will result incidental to project installation is estimated to have an annual value of $731.

Benefits averaging $1,091 annually will accrue to the project from reduction in sediment deposition in Altus Reservoir. Of this amount, $858 will accrue to planned structural measures and $233 to land treatment measures.

It is estimated that the project will produce local secondary benefits averaging $11,957. Secondary benefits from a national viewpoint were not considered pertinent to the economic evaluation.

None of the counties within which the watershed is located have been designated as eligible for assistance under the Area Redevelopment or Economic Development Acts. Consequently, no redevelopment benefits were considered.

The total annual benefits accruing to structural measures are estimated to be $149,845. In addition to the monetary benefits, there are other substantial benefits which will accrue to the project such as an increased sense of security, better living conditions, and improved wildlife conditions. None of these benefits were evaluated in monetary terms nor have they been used for project justification.

COMPARISON OF BENEFITS AND COSTS

Average annual benefits, excluding secondary benefits, which will result from installation of structural measures are estimated to be $137,888. Total average annual project costs are estimated to be $103,415. Of this amount, $75,578 is for installation and operation and maintenance of structural measures and $27,837 is the estimated other economic costs resulting from project development. The benefits will be about $1.33 compared to each dollar of cost.

Total average annual benefits, including secondary benefits, are estimated to be $149,845, giving a benefit-cost ratio of 1.4:1 (table 6).

PROJECT INSTALLATION

Planned land treatment (table 1) will be established by farmers and ranchers during a five-year period in cooperation with Gray County, McClellan Creek and Donley County Soil and Water Conservation Districts. Approximately 65 percent of the land is adequately treated and is being maintained. The goal is to increase the level of land adequately treated to 90 percent during the installation period.

In reaching this goal, it is expected that accomplishments will progress as shown in the following table.

Land Use	Fiscal Year					Total
	1st	2nd	3rd	4th	5th	
	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Cropland	2,875	2,875	2,875	2,875	2,874	14,374
Pasture	133	133	133	133	133	665
Rangeland	8,573	8,573	8,573	8,573	8,572	42,864
Total	11,581	11,581	11,581	11,581	11,579	57,903

Technical assistance in planning and application of land treatment is provided under the going programs of the districts. A standard soil survey is complete for the entire watershed.

The governing bodies of Gray County, McClellan Creek, and Donley County Soil and Water Conservation Districts will assume aggressive leadership in getting an accelerated land treatment program underway.

Landowners and operators will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to landowners in accordance with existing agreements for equipment usage in the districts. The Soil Conservation Service will provide additional technical assistance in accelerating the planning and application of soil, plant, and water conservation measures.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings; preparing radio, television, and press releases; and using other methods of getting information to landowners and operators in the watershed.

Commissioners Courts of Carson and Gray Counties have the right of eminent domain under applicable State law and have financial resources to fulfill their responsibilities.

The Commissioners Court of Carson County will obtain necessary land, easements, and rights-of-way and permits for floodwater retarding structure no. 1. These will then be dedicated to Carson County and McClellan Creek Soil and Water Conservation District.

The Commissioners Court of Gray County will obtain the necessary land, easements, and rights-of-way and permits for floodwater retarding structures nos. 2 through 13. These will then be dedicated to Gray County and Gray County Soil and Water Conservation District.

Commissioners Courts of Carson and Gray Counties will:

1. Determine legal adequacy of easements and permits for construction of structural measures.

2. Provide for relocation or modification of utility lines and systems, roads, and privately owned improvements necessary for installation of structural measures and provide for necessary improvement of bridges and low water crossings on public roads to make them passable during prolonged release flows from structures or permit inundation of such roads and bridges where equal alternate routes are designated for use during periods of inundation.

The Commissioners Court of Gray County will provide necessary legal, administrative, and clerical personnel, facilities, supplies, and equipment to advertise, award, and administer contracts and be the contracting agency to let and service contracts for all structural measures.

Technical assistance will be provided by the Soil Conservation Service in preparation of plans and specifications, supervision of construction, preparation of contract payment estimates, final inspection, execution of certificate of completion, and related tasks necessary to install planned structural measures.

The floodwater retarding structures will be constructed during a five-year installation period in the general sequence as follows:

First Year - Nos. 6 and 7
Second Year - Nos. 1, 2, and 5
Third Year - Nos. 3, 4, and 8
Fourth Year - Nos. 9, 10, 11, and 12
Fifth Year - No. 13

FINANCING PROJECT INSTALLATION

Federal assistance for installing works of improvement described in this plan will be provided under the authority of the Watershed Protection and

Flood Prevention Act (Public Law 566, 83rd Congress; 68 Stat. 666) as amended.

Funds for local share of costs for structural measures will be available from tax supported revenue of Carson and Gray Counties.

It is anticipated that approximately 80 percent of easements will be donated. Out-of-pocket costs for land, easements, rights-of-way, legal expenses, and administration of contracts are estimated to be $130,000.

Sponsoring local organizations do not plan to use the loan provisions of the Act.

Great Plains Conservation Program of the Soil Conservation Service and the soil and water conservation loan program of the Farmers Home Administration is available to all eligible farmers in the watershed. Educational meetings will be held in cooperation with other agencies to outline services available and explain eligibility requirements. Present FHA clients will be encouraged to cooperate in the program.

County Agricultural Stabilization and Conservation committees will continue to provide financial assistance for selected conservation practices.

Structural measures will be constructed during the five-year installation period pursuant to the following conditions:

1. Requirements for land treatment in drainage areas of floodwater retarding structures have been met.

2. All lands, easements, rights-of-way, and permits have been obtained for all structural measures or a written statement furnished by Commissioners Courts of Carson and Gray Counties, that their right of eminent domain will be used, if needed, to secure any remaining land, easements, or rights-of-way within the project installation period and that sufficient funds are available for purchasing them.

3. Court orders have been obtained from appropriate Commissioners Court of Carson and Gray Counties showing that county roads affected by sediment and detention pools of floodwater retarding structures will be either relocated or raised at no expense to the Federal Government, closed, or permission granted to temporarily inundate the roads, provided alternate routes are available.

4. Provisions have been made for improving low water crossings or bridges and/or culverts on public roads or court orders or necessary permits given to temporarily inundate the crossings, providing equal alternate routes are available for use by all people concerned, during

periods when these crossings are impassable due to prolonged flow from the floodwater retarding structures. If equal alternate routes are not available, provisions will be made at no cost to the Federal Government, to make crossings passable during periods of release flow from structures.

5. Utilities, such as power lines, telephone lines, and pipelines, have been relocated or permission obtained to inundate the properties involved.

6. The contracting agency is prepared to discharge its responsibilities.

7. Project agreements have been executed.

8. Operation and maintenance agreements have been executed.

9. Public Law 566 funds are available.

Various features of cooperation between the cooperating parties have been covered in appropriate memoranda of understanding and working agreements.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

Land treatment measures on privately owned land will be maintained by landowners and operators of the farms and ranches on which the measures are applied under agreement with the Gray County, McCellan Creek, and Donley County Soil and Water Conservation Districts. Representatives of the soil conservation districts will make periodic inspections of the land treatment measures to determine maintenance needs and encourage landowners and operators to perform maintenance. They will make district-owned equipment available for this purpose in accordance with existing working agreements. The Forest Service will continue to maintain measures installed on the National Grassland.

Structural Measures

Floodwater retarding structure no. 1 will be operated and maintained by the McClellan Creek Soil and Water Conservation District and Carson County Commissioners Court. Floodwater retarding structures nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13 will be operated and maintained by Gray County Soil and Water Conservation District and Gray County Commissioners Court.

Specific operation and maintenance agreements will be executed prior to issuance of invitations included in the work plan.

Average annual value of operation and maintenance expenses is estimated to be $2,650 for all 13 floodwater retarding structures.

Maintenance will be accomplished through use of contributed labor and equipment, by contract, by force account, or by a combination of these

methods. Operation and maintenance expenses will be paid out of the General Funds of Carson and Gray Counties. Each year the Commissioners Courts of Carson and Gray Counties will budget sufficient funds for operation and maintenance of the structural works of improvement.

Structural measures will be inspected jointly, at least annually and after each heavy stream flow, by representatives of the sponsoring local organizations. A Soil Conservation Service representative will participate in these inspections for a period of, at least, three years following construction of each floodwater retarding structure. The Soil Conservation Service may make other inspections thereafter as it elects to do so.

The Soil Conservation Service will assist in operation and maintenance only to the extent of furnishing technical guidance.

For floodwater retarding structures items of inspection will include, but will not be limited to, condition of principal spillways, earth fills, emergency spillways, vegetative cover, fences, gates, and amount of vegetative growth in reservoirs. These items listed are those most likely to require maintenance.

Provisions will be made for unrestricted access of representatives of the sponsoring local organizations and the Federal Government to inspect the structural measures at any time and for sponsoring local organizations to operate and maintain the structures.

4-24199 5-67

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

McClellan Creek Watershed, Texas

Installation Cost Items	Unit	No. to be Applied Non-Federal Land 2/	Estimated Cost (Dollars) 1/ Public Law 566 Funds	Other Funds	Total
LAND TREATMENT					
Cropland	Acre	14,374	-	409,035	409,035
Pasture	Acre	665	-	20,615	20,615
Rangeland	Acre	42,864	-	187,298	187,298
Technical Assistance			19,610	62,318	81,928
TOTAL LAND TREATMENT			19,610	679,266	698,876
STRUCTURAL MEASURES					
Floodwater Retarding Structures	No.	13	1,504,403	-	1,504,403
Subtotal - Construction			1,504,403	-	1,504,403
Installation Services					
Engineering Services			190,874	-	190,874
Other			129,179	-	129,179
Subtotal - Installation Services			320,053	-	320,053
Other Costs					
Land, Easements, and Rights-of-Way			-	322,483	322,483
Administration of Contracts			-	5,600	5,600
Subtotal - Other			-	328,083	328,083
TOTAL STRUCTURAL MEASURES			1,824,456	328,083	2,152,539
TOTAL PROJECT			1,844,066	1,007,349	2,851,415

1/ Price Base: 1966

2/ For Land Treatment: Acres to be treated during installation period.

January 1967

TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT
(at time of work plan preparation)

McClellan Creek Watershed, Texas

Measures	Unit	Number Applied To Date	Estimated Cost (Dollars) 1/ Non-Federal Land	Federal Land	Total
LAND TREATMENT					
Soil Conservation Service					
Conservation Cropping System	Acre	55,306	446,508	-	446,508
Grassed Waterway or Outlet	Acre	195	28,375	-	28,375
Terrace	Foot	215,614	15,084	-	15,084
Diversion	Foot	423,061	80,961	-	80,961
Irrigation Water Management	Acre	7,011	21,033	-	21,033
Irrigation Land Leveling	Acre	88	6,160	-	6,160
Irrigation System	No.	40	160,000	-	160,000
Irrigation Pipeline	Foot	108,739	177,909	-	177,909
Pasture and Hayland Management	Acre	3,469	4,922	-	4,922
Pasture and Hayland Planting	Acre	1,467	28,455	-	28,455
Range Proper Use	Acre	98,280	215,744	-	215,744
Range Seeding	Acre	3,339	64,341	-	64,341
Brush Control	Acre	3,276	14,742	-	14,742
Farm Pond	No.	53	42,400	-	42,400
Soil Conservation Service - Subtotal			1,306,634	-	1,306,634
Forest Service					
Diversion	Foot	916	-	147	147
Range Proper Use	Acre	1,073	-	1,341	1,341
Range Deferred Grazing	Acre	1,073	-	3,219	3,219
Forest Service - Subtotal			-	4,707	4,707
TOTAL			1,306,634	4,707	1,311,341

1/ Price Base: 1966

January 1967

4-24199 5-67

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION

McClellan Creek Watershed, Texas
(Dollars) 1/

Structure Site Number	Installation Cost - Public Law 566 Funds				Installation Cost - Other Funds			
		Installation Services		Total Public Law 566	Land Easements, and Rights-of-Way 2/	Adm. of Contracts	Total Other	Total Installation Cost
	Construction	Engineering	Other					
Floodwater Retarding Structures								
1	44,892	8,081	4,037	57,010	43,550	400	43,950	100,960
2	167,537	18,429	14,170	200,136	80,795	500	81,295	281,431
3	121,265	15,764	10,442	147,471	9,350	400	9,750	157,221
4	102,289	13,298	8,808	124,395	14,450	400	14,850	139,245
5	78,203	11,730	6,853	96,786	8,355	400	8,755	105,541
6	213,950	21,395	17,933	253,278	39,950	500	40,450	293,728
7	138,912	18,059	11,961	168,932	14,800	500	15,300	184,232
8	99,455	14,918	8,715	123,088	57,563	400	57,963	181,051
9	82,247	12,337	7,207	101,791	18,250	400	18,650	120,441
10	172,203	18,942	14,565	205,710	9,650	400	10,050	215,760
11	56,166	10,110	5,050	71,326	5,750	400	6,150	77,476
12	70,248	10,537	6,156	86,941	5,470	400	5,870	92,811
13	157,036	17,274	13,282	187,592	14,550	500	15,050	202,642
GRAND TOTAL	1,504,403	190,874	129,179	1,824,456	322,483	5,600	328,083	2,152,539

1/ Price Base: 1966

2/ Includes a value of $5,200 for legal expenses.

January 1967

4-24159 9-67

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES

McClellan Creek Watershed, Texas

Item	Unit	Structure Number 1	2	3	4	5	6	7
Drainage Area	Sq.Mi.	17.04	55.97 1/	5.73	6.37	2.13	31.99	12.66
Storage Capacity								
Sediment Pool (50 yr. or 200 ac.ft. limit)	Ac.Ft.	200	200	198	200	200	188	196
Sediment Reserve (Below Riser-50-yr.)	Ac.Ft.	18	397	92	164	86	767	277
Sediment Reserve (Above Riser-100-yr.)	Ac.Ft.	236	657	443	557	362	1,467	729
Sediment in Detention Pool	Ac.Ft.	46	239	122	149	91	410	196
Floodwater Detention Pool	Ac.Ft.	2,618	4,925	666	673	285	2,627	1,127
Total	Ac.Ft.	3,118	6,418	1,521	1,743	1,024	5,459	2,525
Surface Area								
Sediment Pool (50 yr. or 200 ac.ft. limit)	Acre	58	34	22	25	16	38	28
Sediment Reserve (Below Riser-50-yr.)	Acre	62	73	28	37	22	115	65
Sediment Reserve (Above Riser-100-yr.)	Acre	105	116	53	72	49	225	118
Floodwater Detention Pool	Acre	428	360	84	111	71	353	186
Volume of Fill	Cu.Yd.	46,250	180,911	209,000	179,100	115,300	373,250	240,560
Elevation Top of Dam	Foot	3375.2	3197.7	2909.3	2878.3	2820.0	2892.7	2851.9
Maximum Height of Dam	Foot	27	69	67	55	48	49	46
Emergency Spillway								
Crest Elevation	Foot	3371.3	3191.8	2904.8	2873.5	2817.8	2887.0	2846.4
Bottom Width	Foot	250	475	300	225	300	500	275
Type	xxx	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use 2/	xxx	1.0	3.2	2.9	3.8	1.5	3.2	3.2
Average Curve No. - Condition II	xxx	81	81	76	76	76	74	74
Emergency Spillway Hydrograph								
Storm Rainfall 3/	Inch	4.74	5.21	5.20	5.20	5.20	4.48	5.09
Storm Runoff	Inch	2.76	3.17	2.70	2.70	2.70	1.96	2.44
Velocity of Flow (V_c) 4/	Ft./Sec.	0	5.2	3.5	4.1	1.8	3.4	4.6
Discharge Rate	C.F.S.	0	2,098	456	508	23	602	825
Maximum Water Surface Elevation 4/	Foot	3370.6	3193.6	2905.7	2874.7	2818.0	2887.9	2847.8
Freeboard Hydrograph								
Storm Rainfall 3/	Inch	9.48	10.41	10.30	10.30	10.30	8.87	10.08
Storm Runoff	Inch	7.13	8.04	7.28	7.28	7.28	5.72	6.82
Velocity of Flow (V_c) 4/	Ft./Sec.	3.8	10.8	8.6	9.2	6.0	10.0	10.3
Discharge Rate 4/	C.F.S.	4,500	16,846	5,979	5,338	2,005	15,852	9,266
Maximum Water Surface Elevation 4/	Foot	3375.2	3197.7	2909.3	2878.3	2820.0	2892.7	2851.9
Principal Spillway								
Capacity - Low Stage	C.F.S.	168	730	86	86	80	295	127
Capacity Equivalents								
Sediment Volume	Inch	0.55	0.50	2.80	3.15	6.51	1.66	2.07
Detention Volume	Inch	2.88	1.65	2.18	1.98	2.51	1.54	1.67
Spillway Storage	Inch	2.27	0.76	1.17	1.72	3.58	1.49	1.71
Class of Structure	xxx	a	a	a	a	a	a	a

Footnotes on last page of Table 3.

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES - Continued

McClellan Creek Watershed, Texas

Item	Unit	Structure Number 8	9	10	11	12	13	Total
Drainage Area	Sq.Mi.	7.60	6.21	9.02	5.61	5.91	19.62	185.86
Storage Capacity								
Sediment Pool (50 yr. or 200 ac.ft. limit)	Ac.Ft.	199	199	197	30	25	136	2,168
Sediment Reserve (Below Riser-50-yr.)	Ac.Ft.	40	41	135	-	-	-	2,017
Sediment Reserve (Above Riser-100-yr.)	Ac.Ft.	369	365	509	48	45	220	6,007
Sediment in Detention Pool	Ac.Ft.	102	115	135	33	25	146	1,809
Floodwater Detention Pool	Ac.Ft.	791	641	952	448	466	1,277	17,496
Total	Ac.Ft.	1,501	1,361	1,928	559	561	1,779	29,497
Surface Area								
Sediment Pool (50 yr. or 200 ac.ft. limit)	Acre	32	31	23	8	7	31	353
Sediment Reserve (Below Riser-50-yr.)	Acre	37	34	34	-	-	-	507
Sediment Reserve (Above Riser-100-yr.)	Acre	61	64	70	15	10	48	1,006
Floodwater Detention Pool	Acre	106	105	111	49	38	128	2,130
Volume of Fill	Cu.Yd.	150,780	113,500	261,850	88,430	107,700	227,500	2,311,781
Elevation Top of Dam	Foot	2786.2	2804.6	2740.8	2701.5	2696.9	2646.6	xxx
Maximum Height of Dam	Foot	44	40	51	37	43	46	xxx
Emergency Spillway								
Crest Elevation	Foot	2780.7	2800.1	2735.0	2696.5	2691.0	2640.0	xxx
Bottom Width	Foot	200	250	200	200	250	400	xxx
Type	xxx	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	xxx
Percent Chance of Use 2/	xxx	2.7	2.8	2.1	2.8	2.8	2.0	xxx
Average Curve No.-Condition II	xxx	74	74	74	67	67	67	xxx
Emergency Spillway Hydrograph								
Storm Rainfall 3/	Inch	5.20	5.20	5.20	5.20	5.20	4.93	xxx
Storm Runoff	Inch	2.53	2.53	2.53	1.95	1.95	1.76	xxx
Velocity of Flow (V_c) 4/	Ft./Sec.	4.0	3.8	4.3	4.1	4.5	4.7	xxx
Discharge Rate	C.F.S.	403	391	493	428	710	1,304	xxx
Maximum Water Surface Elevation 4/	Foot	2781.8	2801.1	2736.3	2697.7	2692.4	2641.6	xxx
Freeboard Hydrograph								
Storm Rainfall 3/	Inch	10.30	10.30	10.30	10.30	10.30	9.58	xxx
Storm Runoff	Inch	7.03	7.03	7.03	6.10	6.10	5.47	xxx
Velocity of Flow (V_c) 4/	Ft./Sec.	10.0	9.0	10.2	9.6	10.3	10.8	xxx
Discharge Rate 4/	C.F.S.	6,367	5,771	6,838	5,610	8,675	15,912	xxx
Maximum Water Surface Elevation 4/	Foot	2786.2	2804.6	2740.8	2701.5	2696.9	2646.6	xxx
Principal Spillway								
Capacity - Low Stage	C.F.S.	108	62	137	70	75	287	xxx
Capacity Equivalents								
Sediment Volume	Inch	1.75	2.13	2.03	0.37	0.30	0.48	xxx
Detention Volume	Inch	1.95	1.98	1.98	1.50	1.48	1.22	xxx
Spillway Storage	Inch	1.62	1.62	1.49	0.88	0.85	0.92	xxx
Class of Structure	xxx	a	a	a	a	a	a	xxx

1/ Exclusive of area controlled by other structure. This area considered in emergency spillway design.

2/ Based on mass routing of inflow.

3/ Taken from Engineering - Hydrology Memo-TX-1.

4/ Maximum during passage of hydrograph.

TABLE 4 - ANNUAL COST

McClellan Creek Watershed, Texas

(Dollars)

Evaluation Unit	Amortization of Installation Cost 1/	Operation and Maintenance Cost 2/	Other Economic Cost 3/	Total
Floodwater Retarding Structures Numbers 1 through 13	72,928	2,650	27,837	103,415
TOTAL	72,928	2,650	27,837	103,415

1/ Price Base: 1966 prices amortized for 100 years at 3.25 percent.

2/ Adjusted normalized prices.

3/ Estimated reduction of irrigation water yields to W. C. Austin Project, Oklahoma.

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

McClellan Creek Watershed, Texas

(Dollars) 1/

Item	Estimated Average Annual Damages		Damage Reduction Benefits
	Without Project	With Project	
Floodwater			
Crop and Pasture	22,042	3,880	18,162
Other Agricultural	7,164	1,554	5,610
Nonagricultural (Road and Bridge)	3,715	832	2,883
Subtotal	32,921	6,266	26,655
Sediment			
Overbank Deposition	33,453	2,823	30,630
Lake McClellan	3,500	1,900	1,600
Subtotal	36,953	4,723	32,230
Erosion			
Streambank	5,450	0	5,450
Flood Plain Scour	58	25	33
Subtotal	5,508	25	5,483
Indirect	7,539	1,102	6,437
TOTAL	82,921	12,116	70,805

1/ Price Base: Adjusted normalized prices.

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

McClellan Creek Watershed, Texas

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/						Average Annual Cost 4/	Benefit Cost Ratio
	Flood Prevention							
	Damage Reduction	Changed Land Use	Incidental 2/	Outside Project Area 3/	Secondary	Total		
Floodwater Retarding Structures Numbers 1 through 13	60,460	17,789	58,781	858	11,957	149,845	103,415	1.4:1
GRAND TOTAL 5/	60,460	17,789	58,781	858	11,957	149,845	103,415	1.4:1

1/ Price Base: Adjusted normalized prices.

2/ These benefits include $50,443 ground water recharge, $7,607 recreation, and $731 livestock water supply.

3/ Sediment damage reduction benefits to Altus Reservoir.

4/ From Table 4.

5/ In addition, it is estimated that land treatment measures will provide $10,345 damage reduction benefits in the watershed and $233 sediment damage reduction benefits to Altus Reservoir.

INVESTIGATIONS AND ANALYSES

Land Use and Treatment

The status of land treatment for the watershed was developed by the Gray County, McClellan Creek, and Donley County Soil and Water Conservation Districts assisted by personnel from the Soil Conservation Service at Pampa, Panhandle, and Clarendon. Conservation needs data were compiled from existing conservation plans within the watershed and expaned to represent conservation needs of the entire watershed. The quantity of each land treatment practice, or combination of practices, necessary for essential conservation treatment was estimated for each land use by capability class. Acres, by land use, to be treated during the project installation period were estimated (table 1). Hydraulic, hydrologic, sedimentation, and economic investigations provided data as to effects of land treatment measures in terms of reduction of flood damage. Although measurable benefits would result from application of planned land treatment measures, it was apparent that other flood prevention measures would be required to attain the degree of watershed protection and flood damage reduction desired by local people.

Present hydrologic soil and cover conditions were determined by detailed mapping of a 19 percent sample of the contributing portion of the watershed.

Present hydrologic cover conditions for pasture and rangeland were determined on the basis of the percentage of desirable vegetative ground cover and litter. On cropland, hydrologic cover conditions were determined after consultation with local Soil Conservation Service personnel concerning crops grown and rotations followed.

Future hydrologic cover conditions were estimated on the basis of expected percentage of needed land treatment to be applied during the installation period and the probable effectiveness of this application.

Engineering Investigations

A study was made of the watershed to determine where structural measures could be used and, if by including them in the plan, the project objectives for flood prevention and water storage for municipal and recreation use could be attained. The procedure used in making that determination was as follows:

1. A base map was prepared to show the watershed boundary, drainage pattern, system of roads and railroads, and other pertinent information.

2. A study of aerial photographs and U. S. Geological Survey Quadrangle maps supplemented by field examinations indicated locations of probable sites for floodwater retarding structures. By making a stereoscopic study of aerial photographs and quadrangle maps, supplemented by field

examination, it was possible to eliminate those sites which did not have sufficient available storage capacity.

3. The watershed map, showing all possible site locations which might be used to develop a system of structural measures that would meet project objectives, was submitted to sponsoring local organizations. The sponsors provided data on ownership of land apparently involved in each site and cost estimates on necessary easements.

4. Based on apparent physical, economic, and easement feasibility, the sponsoring local organizations and Soil Conservation Service agreed that fifteen possible site locations for floodwater retarding structures would be investigated. Two of these sites (numbers 2 and 13) were to be considered for extra storage of water for recreational development and municipal use. Municipalities expressing an interest in these multiple-purpose uses were Groom and McLean, Texas.

   Permeability tests indicated that sites nos. 2 and 13 do not offer suitable storage potential without treatment to seal the reservoirs. Cost for sealing is excessive and it is anticipated that cost of maintaining the seal would be high.

   Reservoir operation studies indicated that storage for municipal water supply would not be a reliable source of water during the critical drought period. This was due to the inadequate water yield and poor water holding potential at reservoir sites.

5. The drainage area of site 5 has a higher sediment production rate than any area of comparable size in the watershed. Active headcuts have advanced into the upper reaches. Although rapid natural revegetation and flattening of slopes are occurring on streambanks downstream from headcuts, these banks have not become stabilized. Several mechanical methods of treatment, in combination with land treatment, were considered. Shaping, seeding, and fencing was the first alternative considered. The estimated installation and maintenance costs, with allowance for climatic limitations, were excessive. The next alternative was a system of three grade stabilization and sediment control structures. Based on detailed surveys, the estimated cost of three such structures was excessive. The high cost was a result of each structure exceeding design criteria for small dams and exorbitant maintenance requirements for emergency spillways in highly erodable soils where the frequency of use exceeds once in 25 years.

   Because of the steepness of the stream gradient and the high rate of headcutting, there was little assurance that

gully erosion above these sites would be reduced appreciably. The final alternative, the one selected, was one floodwater retarding structure at the lower extremity of the high sediment source area. This structure will have little or no effect on upstream erosion but will trap nearly all the sediment yield from its drainage area.

6. Each site location was classified for limiting design criteria according to damage that would result from a breach of the embankment. All structures were classified as "a".

7. A topographic map of each site was developed to cover pools, dam, and emergency spillway areas. These maps and related surveys provided necessary information to determine if the required sediment and floodwater detention storage capacity could be obtained, limit of the pool areas, estimated installation costs, and the most economical design for each structure.

8. Sediment and floodwater storage, structure classification, and emergency spillway layout and design meet or exceed criteria outlined in Engineering Memorandum SCS-27 and Texas State Manual Supplement 2441.

   Multiple routings of freeboard hydrographs were made to determine spillway proportion and height of dam which would result in the most economical and feasible design of structures. Plans of a floodwater retarding structure, typical of those planned for this watershed is illustrated by figure 2.

9. A detail investigation was made of State, county, and farm roads having crossings on streams below floodwater retarding structures.

   A detail investigation also was made to see what effect floodwater retarding structures would have on State Highways above sites.

10. Structure data tables were developed to show the following for each structure: drainage area, capacity needed for floodwater detention and sediment storage; release rate of principal spillway; acres inundated by sediment, sediment reserve, and detention pools; volume of fill in dam; estimated costs of the structure; and other pertinent data (tables 2 and 3).

    Foundation investigations showed a majority of the structures required either abutment drains, foundation drains, embankment drains or a combination of these drains to insure stability of the embankments.

All the floodwater retarding structures were planned with reinforced concrete principal spillways which will drain the detention pool after inflow ceases in 10 days or less. Plunge basins were planned at the terminal end of each principal spillway to de-energize the velocity of the release floodwaters.

When the structural measures for flood prevention had been determined, a table was developed to show the total cost of each structure (table 2).

A second cost table was developed to show separately the annual installation cost, annual maintenance cost, and total annual cost of structural measures (table 4).

Hydraulic and Hydrologic Investigations

The following steps were taken as part of the hydraulic and hydrologic investigations:

1. Basic meteorologic and hydrologic data were tabulated from U. S. Weather Bureau climatological Bulletins for the rainfall gage at Pampa and Shamrock, Texas, and U. S. Geological Survey Water Supply Papers for stream gage data. These data were analyzed to determine seasonal distribution of precipitation, rainfall-runoff relationships, and monthly runoff volumes.

2. The present hydrologic conditions of the watershed were determined on the basis of cover conditions, land use and treatment, soil groups, and crop distribution. The average condition II curve number of 78 for the hydrologic soil-cover complex was determined from a 19 percent sample of the watershed.

   The future project conditions were determined by analyzing results of land treatment and structure location that would be applied during the installation period. This study revealed that an average condition II curve number of 77 is applicable.

3. Engineering surveys were made of valley cross-sections, high water marks, bridges, and other features pertinent in determining the extent of flooding. The cross-sections were selected to represent stream hydraulics and flood plain area, and final locations were made after joint study with the economist and geologist.

4. Cross-section rating curves for McClellan Creek were developed from field survey data collected in 3, above, by water surface profiles using the computer service at the Fort Worth E&WP Unit.

5. Stage-area inundated curves were developed from field survey data for each portion of the valley represented by a cross-section. Area inundated data by incremental depths of flooding were developed for each evaluation reach, using runoff-peak discharge relationship for storms in the evaluation series.

6. Present and project condition runoff-discharge relationships were determined by flood routing the 3.30 inch rainfall, 48-hour duration. Present and project condition peak discharges were then determined for the rainfall events of the evaluation series.

   Routings and hydrograph development were made by use of the IBM 7090 computer, as described in Technical Release No. 20, Project Formulation.

7. Determinations were made of the area that would have been inundated by storms of the evaluation series under each of the following conditions:

   a. Without project condition.

   b. Installation of land treatment measures for watershed protection.

   c. Installation of land treatment and structural measures.

8. From a tabulation of cumulative departure from normal precipitation, the period 1940 through 1965 was determined to be representative of the normal precipitation on the watershed, and is the period from which the historical evaluation series was developed. The largest storm in the series approached the 26-year frequency storm for the watershed.

9. The maximum release rates for the principal spillways of the floodwater retarding structures were designed to drawdown the detention pool volume in 10 days.

10. The appropriate emergency spillway and freeboard design storm were selected in accordance with criteria contained in NEH, Chapter 21, Section 4, Hydrology, Part I - Watershed Planning.

11. Coordinated studies were made jointly by the Soil Conservation Service and the Bureau of Reclamation to determine the total effect of the installation of the 13 planned floodwater retarding structures upon water yields from Altus Reservoir. The Soil Conservation Service made reservoir operation studies of the planned floodwater retarding structures according to procedures outlined in Chapter 2, Texas Engineering Handbook, Section 4, Hydrology. The Service and the Bureau jointly made studies to determine the effects of the floodwater retarding structures

upon the inflow to Altus Reservoir. The Bureau made reservoir operation studies to determine the effects upon the yield of water from Altus Reservoir. The Service and the Bureau concur in the results of these studies.

Sedimentation Investigations

Sedimentation investigations were made in accordance with procedures as outlined in Guide to Sedimentation Investigations, South Regional Technical Service Area, March 1965, Fort Worth, Texas; Technical Release No. 17, "Geologic Investigations for Watershed Planning", March 1966; Technical Release No. 12, "Procedure for Computing Sediment Requirements for Retarding Reservoirs", September 1959; and Technical Release No. 25, "Planning and Design of Open Channels", December 1964.

Sediment Source Studies

Sediment source studies to determine 100-year sediment storage requirements were made in drainage areas of the thirteen planned floodwater retarding structures. Detailed investigations were made in five of these drainage areas. Investigations on the Southern High Plains were done on the basis of a 15 percent sample. Estimates of sediment production rates for the eight structures not studied in detail were based on data gathered in detailed investigations.

The five detailed investigations and computations included:

1. Mapping soils by units, percent slope, length of slope, land use, cover condition classes on rangeland and pasture, land treatment on cultivated land, and land capability classes.

2. Measuring lengths, widths, and depths, and estimating rates of annual lateral erosion of all gullies and stream channels affected by erosion.

3. Studying old aerial photographs and making field measurements of widths and depths of overfalls to determine average annual headward erosion of gullies.

4. Computing average annual erosion by sources (Sheet, gully, and streambank). The soil loss equation by Musgrave was used in sheet erosion computation.

Field studies and computations for the eight planned structures not surveyed in detail included:

1. Mapping land use.

2. Studying soils, geology, topography, and erosion for comparison to drainage areas surveyed in detail.

3. Computing average annual erosion based on erosion rates of detailed areas.

4. Making detailed studies and computations of gully and streambank erosion where these are significant sources of sediment.

Estimates of annual gross erosion reflect the effect of expected land treatment on drainage areas of planned structures. A gradual improvement of watershed conditions is expected as a result of installation of planned land treatment measures.

Sediment storage requirements for planned structures were determined by adjusting total average annual erosion for expected sediment delivery ratios and trap efficiency. Allowance was made for the difference in density of soil in place and sediment submerged in pools of floodwater retarding structures. Based on the unit dry weight of upland soil samples in the watershed and submerged sediment samples in the vicinity, estimated volume weights ranged from 81 to 90 pounds per cubic foot for soil in place and 49 to 75 pounds per cubic foot for submerged sediment. At structure sites where the anticipated sediment yield is to be derived from the fine textured soils of the High Plains and portions of the escarpment area, the lighter volume weights were used. The heavier volume weights were used for structure sites with drainage areas of coarse textured soils.

Allocation of sediment to the pools of floodwater retarding structures was based on 68 to 85 percent deposition in sediment and sediment reserve pools and 15 to 32 percent in detention pools.

Flood Plain Sediment and Scour Damages

The following investigations and computations were made to determine the nature and extent of physical damage to flood plain lands and the effect of the project on these damages:

1. Borings were made along valley cross-sections (figure 1). Factors such as depth and texture of sediment deposits, depth to the water table, soil condition, depth and width of scoured areas, channel degradation or aggradation, and channel bank erosion were recorded.

2. The elevation of the original flood plain before modern deposition began was estimated for each valley cross-section.

3. Estimates of past rates of land loss by channel widening and other physical flood plain damage were obtained through interviews with landowners and operators.

4. A damage table was developed to show percent damage by texture and depth increment for sediment and by depth and width for scour. Due consideration was given to

agronomic and land treatment practices, soils, crop yields, and land capabilities in assigning damages.

5. The depth and width of modern alluvial deposits and scoured areas were measured and tabulated.

6. The damage areas were grouped by segments. Within each segment the area for each depth increment of deposition and scour was computed.

7. Damage to productive capacity of flood plain land was assessed, by percent, for each computed damage area.

8. Sediment and scour damages were summarized, by evaluation reaches, for the entire flood plain and adjusted for recoverability of productive capacity. Estimates of recoverability of productive capacity were developed from field studies and interviews with farmers and ranchers.

9. The average annual sediment yield from each source (sheet erosion, gully erosion, streambank erosion, and flood plain scour) was estimated based on detailed sediment source studies and scour damage investigations. Sediment yields to evaluation reaches were computed for without-project conditions, with land treatment measures applied, and with the combined program of land treatment and structural measures installed.

   Reduction in sediment yield was adjusted to reflect the relative importance of each sediment source as a contributor of damage. Reduction of monetary damage from overbank deposition was based on the reduction of area inundated by floodwater and reduction in damaging sediment yield.

10. Estimates of reduction of scour damage due to installation of the project were based on reduction of depth and area inundated by floodwater.

Reservoir Sedimentation

Studies of sediment sources in McClellan Creek watershed were used as a basis for estimating the effects of the project on sediment deposition in Lake McClellan and Altus Reservoir. Sediment delivery ratios were estimated by sources, making allowances for such factors as size, shape, topography, and relief-length ratio of the watershed; density, drainage pattern, gradient, and capacities of channels; and texture of sediment.

The average annual sediment yield to Lake McClellan is expected to be reduced from 35 to 19 acre-feet as a result of installation of land treatment measures and floodwater retarding structures nos. 1 and 2.

McClellan Creek watershed constitutes 10 percent of the drainage area of Altus Reservoir. The estimated average annual sediment yield to Altus Reservoir from McClellan Creek watershed is 22 acre-feet. This is two percent of total deposition. As determined by sedimentation surveys made by the Bureau of Reclamation, United States Department of the Interior, total annual sediment deposited in Altus Reservoir averages 1,130 acre-feet per year. An average annual reduction of 14 acre-feet of sediment deposition in Altus Reservoir is expected as a result of installation of land treatment measures and floodwater retarding structures on McClellan Creek watershed.

Channel Stability Studies

Channel stability studies were made on evaluation reaches 1, 2, and 3 (figure 1). Hand auger borings were made at valley cross-sections to study the nature of bedload materials.

The bedload, definitely non-cohesive, is primarily fine to medium grained sand classified as SP in accordance with the Unified Soil Classification System. The average thickness of this bedload is greater than 10 feet. Based on median grain size of bedload, the application of critical tractive force values indicated decisive bedload movement in the three reaches.

The Schoklitsch bedload transport equation was applied to relate incoming bed material with transport capacity at each valley cross-section. Estimated stream channel behavior under present conditions was compared with that under project conditions, using both the 10-year frequency and the annual storm in the equation. Pronounced aggradation was indicated, except immediately downstream from Lake McClellan, for present conditions using both storms. With project conditions, a reversal from an aggrading channel to one of stability or slight degradation was indicated for all three reaches. Studies indicate that the new channel regimen will include virtual elimination of land loss by stream channel encroachment and slight lowering of the water table in the valley alluvium.

Geologic Investigations

Preliminary geologic investigations were made at each of the floodwater retarding structure sites to obtain information on water tables, nature and extent of embankment materials, types of materials in emergency spillway excavation, and emergency spillway stability. These investigations included surface observations of valley slopes, alluvium, channel banks, and exposed geologic formations, hand auger borings, core drill borings, and field permeability (well permeameter tests). Core drill borings were made at site nos. 2, 6, and 13 to aid in making more accurate estimates of construction problems. These investigations were also used to aid in determination of suitability of site nos. 2 and 13 for use as multiple purpose structures. Samples of foundation and embankment materials were submitted for analyses to the Materials Testing Section in Fort Worth, Texas. Tests performed included Atterberg limits, mechanical analysis, percent dispersion, soluble salt content, triaxial shear, compaction, dry unit weight, and slope stability.

Findings of geologic investigations were used in making cost estimates of structures and to assure that sites selected are feasible for construction.

Description of Problems

Sites nos. 2, 4, 5, 6, 7, 8, and 9 are located entirely on the outcrop of the Ogallala formation of the Tertiary system. The formation is made up of thick and extensive deposits of Pliocene outwash, derived primarily from the Rocky Mountains and consists of beds and lenses of dense sand, silt, clay, and gravel partially cemented with calcium carbonate. Secondary deposits of caliche are common within the formation. Sites nos. 3, 10, and 13 are located partially on the Ogallala outcrop. Shales of the Quartermaster formation of the Permian system underlie the Ogallala formation and are exposed at these three sites. Sites nos. 11 and 12 are located entirely on the outcrop of the Quartermaster formation. Site no. 1, the only site located in the Southern High Plains, lies upon Quaternary deposits. These are primarily eolian sandy clays, which are underlain at shallow depth by the Ogallala formation.

Permeable foundation materials occur at all floodwater retarding structure sites. These materials range from moderately permeable, slightly cemented, silty sands of the Ogallala formation to highly permeable, loose, alluvial sands. Drainage measures will be needed at all sites. It is estimated that relief wells will be needed at sites nos. 1 and 2 where clay blankets overlie the Ogallala formation. Sites nos. 3, 4, 8, 9, and 11 will need foundation drains. Sites nos. 5, 6, 7, 10, 12, and 13 are expected to require a combination of embankment and foundation drains, including vertical relief drains.

High water tables will hamper construction operations and limit the depth of borrow excavation in the lower portion of the watershed. This is especially true at sites nos. 6, 7, 10, 12, and 13.

All embankments except those of sites nos. 1 and 2 are expected to be zoned. The dominant soils available at these two sites are classified as CL in accordance with the Unified Soil Classification System. Alluvial soils for embankments at sites nos. 10, 11, 12, and 13 consist mostly of SM and SP. Cementing properties of these soils are pronounced because of high calcium carbonate content. A limited supply of CL and SC is available at these sites from weathered Permian shale and from emergency spillway excavation. Embankment materials for sites nos. 3, 4, 5, 6, 7, 8, and 9 consist mostly of SC, CL, and SM.

There will be no rock excavation in emergency spillways.

Core drill borings and field permeability tests indicate that sites nos. 2 and 13 do not offer water storage potential suitable for inclusion as multiple purpose structures.

Further Investigations

Detailed investigations, including exploration with core drilling equipment, bulldozer, and/or back-hoe will be made at all sites prior to final design.

Laboratory tests will be made to determine suitability and methods of handling foundation and embankment materials.

Ground Water Investigations

A ground water investigation was made to determine the following: effect of the project on ground water; the dependability of floodwater retarding structure sites for storage of water for municipal or recreational use; and the effect of ground water on construction of floodwater retarding structures.

Pertinent information was gathered from recent publications concerning ground water in the vicinity of the watershed. Borings were made with hand auger and core drilling equipment at three floodwater retarding structure sites and at valley cross-sections.

The following are pertinent facts considered in making the investigation:

1. The Ogallala formation, principal source of water in the Southern High Plains, underlies most of the watershed but thins abruptly in the eastern portion. Generally, the saturated thickness of the formation is insignificant east of valley section 6 (figure 1).

2. In the vicinity of the watershed, the Ogallala formation ranges in thickness from 0 where Permian shales crop out to about 600 feet in Carson County and lies unconformably on an erosional surface of Permian shales, snadstones, and conglomerates. For practical purposes, these rocks form the base of the aquifer.

3. Downward cutting of the Pecos and Canadian Rivers has cut off the original source of fresh water replenishment which was runoff from the mountains to the west and northwest. The present source of water in the aquifer is precipitation that falls on the surface of the plains. This is almost negligible because of slow permeability rates of most soils which blanket the Southern High plains surface.

4. Water in the formation generally occurs under water table conditions. Movement is generally toward the east. The water table slopes in this same direction at about 10 feet per mile. The rate of movement is approximately two inches per day.

5. Water in the formation is generally of good chemical quality except that it is hard and has high silica content. Most of the water is suitable for irrigation and domestic supplies.

6. Since 1954, when large scale irrigation began in Carson County, the water level in the Ogallala formation has been

declining appreciably. It has declined a maximum of approximately 30 feet in Carson County and 3 feet in Gray County. In some wells, remote from pumping for irrigation, water levels have risen. Depth to the water table beneath the plains surface ranges from about 200 to 350 feet.

7. Artificial recharge has been attempted in the Southern High Plains Land Resource Area with varying degrees of success, but is not practiced on a large scale at present. The principal problem is clogging of pore spaces by sediment, organic materials, and chemical and physical reactions.

Field studies indicate that fine textured soils of medium consistency, classified mostly as CL in accordance with the Unified Soil Classification System, blanket the more permeable Ogallala formation in the flood plain and stream channel of evaluation reaches 4 and 5 (figure 1) and pool areas of sites nos. 1 and 2. The average thickness of this blanket is about 15 feet. Its permeability rate, at 1:1 head, is about 0.10 foot per day. Permeability rates of clay beds of the underlying Ogallala formation are about 0.20 foot per day. Permeability rates of the sands of the Ogallala formation are much greater.

Darcy's law was used in estimating rates of water seepage through soils of stream channel of reaches 4 and 5 under present conditions and through reservoir bottoms of sites nos. 1 and 2 and stream channel of reaches 4 and 5 under project conditions. Estimates of evaporation losses were taken into account.

It is estimated that recoverable ground water recharge will be increased by 1,860 acre-feet annually as a result of the installation of floodwater retarding structures nos. 1 and 2. This increase can be expected as a result of impoundment of water over the flood plain and valley walls and prolonged release flows in channels.

Increased recharge is expected to have negligible effect outside the watershed because of the slow rate of lateral movement of ground water.

Downstream from Lake McClellan (evaluation reaches 1, 2, and 3) the Ogallala formation and Permian shales are overlain by extensive alluvial deposits in the valley of McClellan Creek. This alluvium is composed of fine to medium grained sand and silty sand containing some thin beds and lenses of clay and silt. It contains an aquifer, ranging in thickness to more than 100 feet, with a base at the upper surface of Permian strata. The hydraulic gradient is in the general direction of stream flow. This aquifer is recharged by water discharged from the Ogallala formation and by seepage of runoff water into stream channel sands.

The water table is at or very near stream channel bottom elevations in reaches 1, 2, and 3 and all floodwater retarding structure sites except nos. 1 and 2. Thus, there is little opportunity for increasing ground

water recharge with structures nos. 3 through 13 while the water table is at its normal position. With present pumping rates in the valley, natural recharge is sufficient to maintain the water table near the stream channel bottom, except during dry periods. Assuming an increased number of wells and incrased acreage irrigated in the flood plain causing a decline of the water table, all floodwater retarding structures would prove valuable in recharging this aquifer.

No benefits were claimed for increased ground water recharge as a result of the installation of floodwater retarding structures nos. 3 through 13.

Economic Investigations

Selection of Evaluation Reaches

In order to determine flood damages and make appropriate evaluations of the damages in the flood plain and to determine the effects and the benefits of proposed structural measures, the watershed was divided into five separate evaluation reaches (figure 1).

Determination of Flood Damages

During economic investigations in the watershed, damage schedules were obtained from flood plain landowners, county and State road officials, local agricultural technicians, and other agricultural leaders. Schedules were obtained covering about half the flood plain. Information collected was used to determine crop distribution, flood-free yields, expected changes and trends in agricultural economy, past history of flooding and related damages, and other data needed to make estimates for the economic evaluations.

Flood plain land use and damageable values were determined. A separate damageable value was determined for each evaluation reach. Flood damage to crops, pastures, and other agricultural and nonagricultural properties was determined by using a historical storm series covering a 26-year period from 1940 through 1965. Damages were related to area inundated and depth of inundation. Crop and pasture damage was related to growing seasons. Damage rates by depth of flooding were based on information given in Soil Conservation Service Economics Memorandum TX-11 and were adjusted for local watershed conditions. Allowances were made to reflect less damage from recurrent flooding during the same cropping season. Crop and pasture damage was discounted, where applicable, to reflect the land loss expected to occur, because of flood plain streambank erosion, in absence of a project.

Flood plain areas that will be inundated by pools of structures were excluded from areas on which damages were calculated.

Damage to agricultural property such as fences, farm roads, creek crossings, livestock, and debris deposits on land was estimated from information collected in the field.

Road and bridge damage estimates were based on information obtained from County and State road officials, from landowners, and from a physical check

of improvements subject to flood damage. The estimates were related to size and frequency of floods as reflected by high water elevations.

Monetary value of the physical damage to flood plain land from deposition of sediment and from scour was based on value of production lost. Allowances were made for time lag necessary for recovery and for the non-recoverable loss in production. The monetary damage from permanent loss of land by erosion was estimated using the procedure outlined in Chapter 5, paragraph number IIA, of the Soil Conservation Service Economics Guide. Flood plain scour damage was related to depth of flooding with weight given to increased velocity from the deeper flows. Reductions in damage from sediment deposition and from permanent land loss was based on the effectiveness of land treatment, the trap efficiency of planned floodwater retarding structures, and the reductions in average annual area flooded.

The monetary value of sediment damage to Lake McClellan and to Altus Reservoir was based on replacement cost estimates of installations having the same facilities and the same acre-feet of water storage capacity. The "straight-line" method was used to calculate the monetary sediment damage per acre-foot. The cost per acre-foot of storage for Lake McClellan is estimated to be $100 and for Altus Reservoir the cost is estimated to be about $78.

Indirect damage involve such items as interruption of travel, re-routing and delays of school buses and mail deliveries, and losses in business sustained by business establishments in the trade area. Inconvenience and delays in caring for livestock at times when creeks are flooding is an indirect damage. It is estimated that 10 percent of the direct damages would be an equitable estimate for indirect damage.

Benefits from Reduction of Damages

Floodwater, sediment, erosion, and indirect damages were calculated for each reach under the following conditions: without project, with land treatment, and with land treatment and structural measures. The difference between the average annual damage for each progressive increment of protection constitutes damage reduction benefits assigned to the increment.

Benefits from Restoration and Changed Land Use of Flood Plain Land

Field investigations were made to determine what changes had occured in flood plain land use as a result of past floods. Investigations were made to determine what changes would occur if flooding was reduced.

It was found that as a result of past floods and related sediment deposits, a majority of the flood plain land, especially in reach 1, has been converted from hay meadows to rangeland or idle land.

Farmers and ranchers indicated that when flooding and sediment deposition is reduced, the land would be restored and/or changed to hay meadows. Fertilization and proper hayland management will help restore the land to its former use.

Landowners and operators statements were considered along with the land capabilities and general agricultural economic conditions and trends in making the estimates of benefits from restoration and changed land use. Consideration was given for added damage from remaining flooding to higher damageable values. Additional costs of production and harvesting with associated expenses were deducted from the expected increased value of production. Adjusted normalized prices were used. The benefits were discounted to allow for a 10-year lag in accrual. The changed land use benefits resulting from shifts of portions of the present stream channel to hay production have been further discounted to allow for a net average annual change in equal amounts each year from the 10th year of the period of project life to the 60th year. The restoration benefits have been included in crop and pasture and sediment damage reduction evaluations as shown in table 5.

Incidental Benefits from Recreation

Water-based recreation benefits will occur incidental to the installation of some of the floodwater retarding structures. Flood prevention was the only purpose considered in the location of these structures and no additional Public Law 566 costs are involved in obtaining the recreation benefits. When the structures are installed, it is estimated that sediment pools will have an initial total capacity of 1,775 acre-feet of water storage and a surface area of 312 acres. With the expected sediment deposition in the sediment pools, the capacity will eventually decline to zero.

Present water-based facilities do not meet the needs of the people in the area. The pools of water in six of the structures will provide additional facilities for fishing and some swimming, boating, camping, and picnicking. Pools are expected to be open to the public, but some will be open on a fee-charge basis or by free admission with the landowners permission.

Factors considered in making the estimates of incidental recreation benefits were: population within a radius of 75 miles, size of pools, accessibility of the site and the estimated water-holding potential of each site. The expected use of the six sites was estimated to be 20,000 visitor days annually having a value of 50 cents per visitor-day. An allowance was made to cover operation and maintenance costs associated with recreation activities. The benefits were discounted to show full use for 40 years with a decline to no use by the 50th year.

Water yield studies indicate an adequate water supply will be available for the activities which produce the recreation benefits.

Incidental Benefits from Ground Water Recharge

Additional ground water recharge of the Ogallala formation will occur incidental to the installation of two of the floodwater retarding structures. No additional costs will be involved in obtaining this recharge since it will occur naturally. Some floodwater detained by structures will penetrate down into the Ogallala formation and remain in place. Since it has been estimated that the ground water supply for irrigation eventually will

be depleted, it is estimated that each additional acre-foot of recharge will be used for irrigation.

The Bureau of Reclamation estimates the value of an acre-foot of water for irrigation in the W. C. Austin Project, Oklahoma, to be $40.00. The additional water made available for irrigation as the result of increased recharge was considered to have an equal value less the cost of recovery. After allowance for cost of recovery, the net value per acre-foot of recharge is estimated to be $27.12.

When the structures are installed, it is estimated that the volume of additional average annual recharge will be 1,860 acre-feet and have a net value of $50,443.

Secondary Benefits

Values of local secondary benefits and local secondary losses were calculated in accordance with the interim procedures outlined in Watersheds Memorandum SCS-57, dated October 3, 1962.

Benefits of a local nature were considered as either (1) stemming from the project or (2) induced by the project. Benefits stemming from the project were estimated to be 10 percent of the direct damage reduction benefits accruing to structural measures. Benefits induced by the project were estimated to be 10 percent of the incidental benefits and 10 percent of the increased costs involved with changed land use.

Secondary losses resulting from installation of structural works of improvement were calculated in the same manner as secondary benefits.

Appraisal of Land and Easement Values

Areas that will be used for project construction and areas to be inundated by pools of reservoirs were determined. Net income from production to be lost in these areas after installation of the project was compared with the appraised value of the land amortized over the period of project life. It was considered there would be no production in the sediment pools and that all land covered by the detention pools would be grassland. The value of land and easements for the structures were determined by appraisal in cooperation with representatives of the sponsoring local organizations. The structure site costs were based on the value of the easements.

The annual net loss in production and associated secondary losses, based on adjusted normalized prices, on land to be utilized by the structures were calculated and compared with the amortized cost of the structure sites. Site costs exceed value of annual production losses and associated secondary losses; therefore, the structure site costs were used in economic evaluations.

Fish and Wildlife Investigations

The Bureau of Sport Fisheries and Wildlife, in cooperation with the Texas Parks and Wildlife Department, has completed a reconnaissance study on McClellan Creek watershed. This report was valuable in work plan development pertaining to fish and wildlife. In addition to data presented in other parts of the work plan, the following recommendations are reproduced from the Bureau of Sport Fisheries and Wildlife reconnaissance survey report:

> "Often, in the construction phase of a project of this type, a few minor changes in design, construction, and management procedures would greatly reduce the destruction of and improve fish and wildlife habitat. These changes could have surprisingly beneficial effects on fish and wildlife populations for many years.
>
> Basins of the floodwater retarding impoundments, immediately after completion and prior to storage of water, should be disked and planted to suitable grains or grasses which are adaptable to the area. Such plantings would reduce turbidity and increase the fertility and the productive capacity of the waters in the impoundments.
>
> Floodwater retarding reservoirs should be fenced, when practicable to prevent damage to the dams and muddying of the water by livestock. Watering devices, if required, should be installed below the dams and outside the enclosures. These measures would not only improve the quality of fish habitat, but also would provide more desirable water and watering condition for livestock.
>
> Lands in the vicinity of floodwater retarding dams and reservoirs should be planted to native or adaptable grasses to prevent soil erosion and deposition of sediment in the basins of the impoundments. These measures would improve fish habitat by the reduction of turbidity of the water.
>
> Stocking of fish in floodwater retarding reservoirs should be done under the guidance of the Texas Parks and Wildlife Department. Unwise stocking of impoundments could result in the presence of undesirable fishes and in high populations of stunted fishes.
>
> During the construction phase of the project, timber clearing should be kept to a minimum where possible. Minimal timber clearing would not only reduce construction costs but would retain much of the original wildlife habitat of the area.
>
> Improvement of wildlife habitat would be achieved by the planting of wildlife food and cover plants. Planting should be made particularly in eroded areas and gullies as well as impoundment enclosures, and along fencerows and driveways. Such plantings also would add to the esthetic value of the area.

It is recommended:

1. That the basins of floodwater retarding reservoirs be disked and planted to a suitable cover crop upon completion and prior to storage of water.

2. That floodwater retarding dams and reservoirs be fenced, when practicable, and watering devices be installed below the dams and outside the enclosures, if necessary.

3. That lands devoid of vegetation in the vicinity of floodwater dams and reservoirs be planted to native or adaptable grasses to prevent soil erosion and deposition of sediment in the basins of these impoundments.

4. That the stocking of fish in the floodwater retarding reservoirs be done under the guidance of the Texas Parks and Wildlife Department.

5. That the clearing of brush and timber be kept to a minimum throughout the construction of the project.

6. That wildlife food and cover plants be planted in eroded areas, gullies, impoundment enclosures, and along fencerows and driveways.

The above recommendations are in conformance with U.S.D.A. Soil Conservation Service Biology Memorandum 7 (Rev. 1), National Standards for Biology Practices. If adopted as a part of the plan of development, losses of wildlife habitat would be mitigated and, additionally, fish and wildlife benefits would accrue to the project.

A detailed study of the watershed by the Bureau of Sport Fisheries and Wildlife is not considered necessary at this time. Should the sponsors desire detailed information on planning for wildlife habitat management, our Bureau, in cooperation with the Texas Parks and Wildlife Department, would be happy to be of further assistance."

4-24199 9-67

FIGURE 1

PROBLEM LOCATION MAP

Mc CLELLAN CREEK WATERSHED

CARSON, DONLEY AND GRAY COUNTIES, TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

COMPILED FROM COUNTY GENERAL HIGHWAY MAPS

REV 6-67 1-67 4-R-23437

Rev 1-67 NOVEMBER 3, 1965 4-R-20740

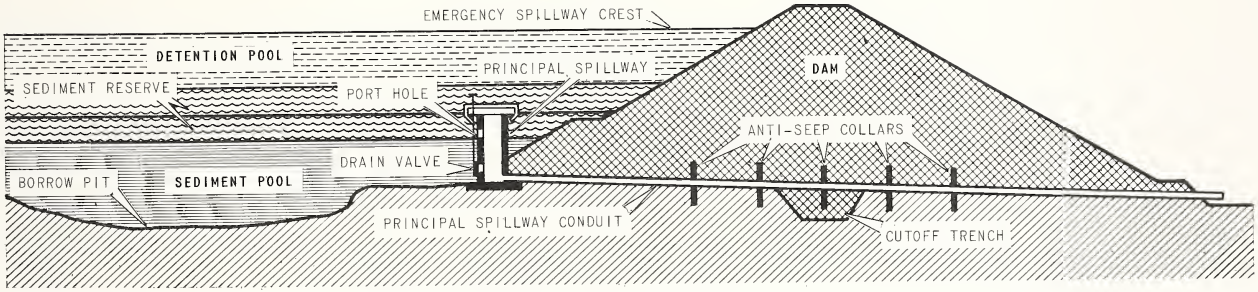
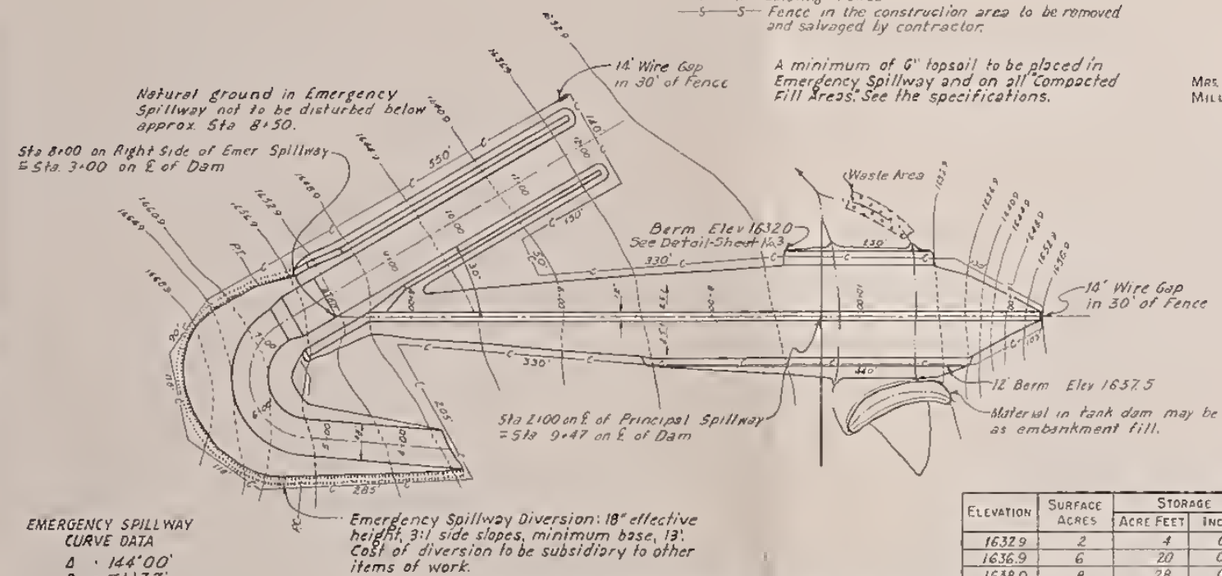


Figure 2

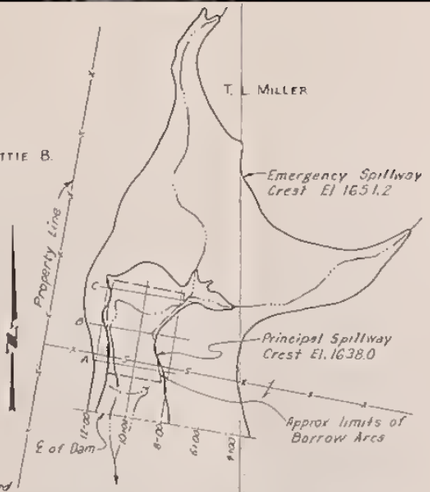
SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

FENCE LEGEND
—C—C— Fence to be constructed under contract
—X—X— Existing Fence
—S—S— Fence in the construction area to be removed and salvaged by contractor.



EMERGENCY SPILLWAY CURVE DATA
Δ = 144°00'
D = 71°37'
R = 80.35'
L = 201.0'
P.C. = Sta. 5+29
P.T. = Sta. 7+30

PLAN OF EMBANKMENT AND SPILLWAYS
0 100 200 300 400 500
SCALE IN FEET



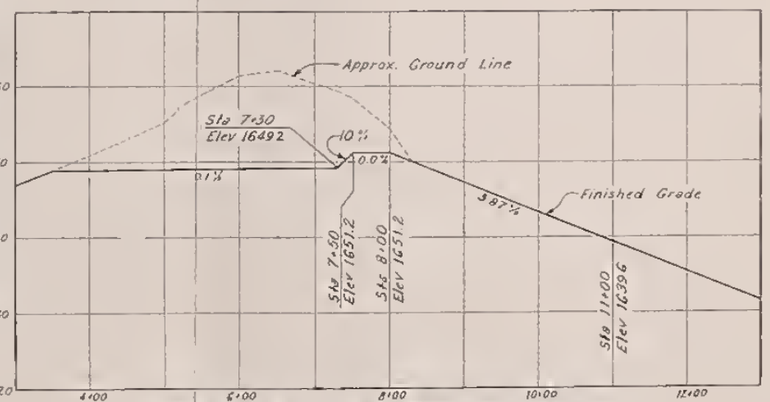
GENERAL PLAN OF RESERVOIR
0 400 800 1200 1600
SCALE IN FEET

Structure located approximately 12 miles northeast of Coleman, Coleman County, Texas

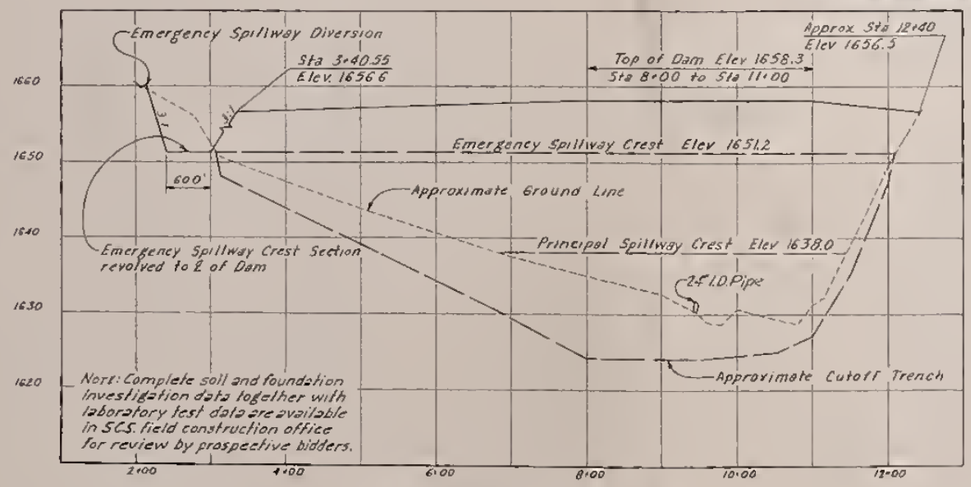
VICINITY MAP
0 1 2 3 4
SCALE IN MILES

ELEVATION	SURFACE ACRES	STORAGE ACRE FEET	STORAGE INCHES
1632.9	2	4	0.05
1636.9	6	20	0.27
1638.0	8	28	0.37
1640.9	14	60	0.80
1644.9	20	128	1.70
1648.9	29	226	3.00
1651.2	36.4	301	3.99
1652.9	41	368	4.88
1656.9	53	558	7.40
1660.9	64	792	10.51

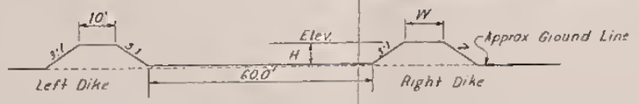
Top of Dam (Effective) Elev.	1656.5
Emergency Spillway Crest Elev.	1651.2
Principal Spillway Crest Elev.	1638.0
Sediment Pool Elev.	1638.0
Drainage Area, Acres	904
Sediment Storage, Acre Feet	32
Floodwater Storage, Acre Feet	269
Max. Emergency Spillway Cap., c.f.s.	1830



PROFILE ON ℄ OF EMERGENCY SPILLWAY



PROFILE ON ℄ OF DAM



Left Dike
Approx Sta. 7+75 to Sta 8+00 Elev 1656.6 From Sta 8+00 to Sta 8+50, grade uniformly to H=30.' From Sta. 8+50 to 12+00, H=30.'

Right Dike
Approx Sta 7+40 to Embankment Elev 1656.6, W=14.0', Z=2.5:1. From Embankment to Sta. 9+00 Transition Section. Sta 9+00 to Sta. 12+00 H=30.' W=10.0', Z=3:1.

Note:
Material forming both dikes to be placed and paid for as "Compacted Fill"
Natural ground in Emergency Spillway not to be disturbed below approx Sta 8+50

TYPICAL SECTION — EMERGENCY SPILLWAY

Figure 3

TYPICAL
FLOODWATER RETARDING STRUCTURE
GENERAL PLAN AND PROFILE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed W.E.C.	Date 3-61	Approved by:	
Drawn W.E.C. & H.R.T.	3-61		
Traced H.R.T.	3-61	Sheet No. 2 of 8 sheets	Drawing No. 4-E-15,357
Checked W.E.C. & G.W.T.	4-61		

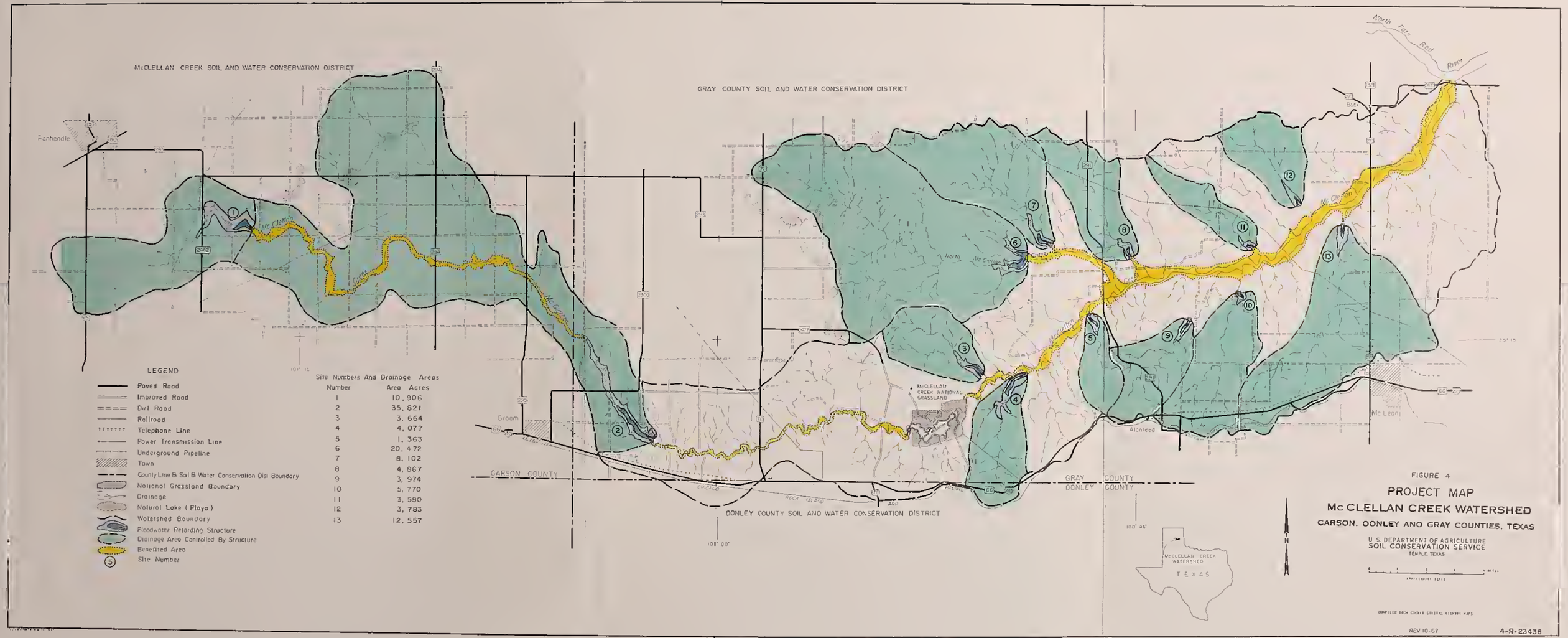


FIGURE 4

PROJECT MAP

Mc CLELLAN CREEK WATERSHED

CARSON, OONLEY AND GRAY COUNTIES, TEXAS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEMPLE, TEXAS

REV 10-67 4-R-23438

Rev 1-67 NOVEMBER 4, 1965 4-R-20740